Centre for Marine and Coastal Studies Ltd

Ormonde Offshore Wind Farm

Boat-based Ornithological Monitoring Report 2014

Commissioned by Vattenfall Wind Power Limited

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This report has been prepared by Centre for Marine and Coastal Studies Ltd (CMACS) on behalf of RPS Group plc.

Cover image: Manx shearwater *Puffinus puffinus* taken during wind farm related bird surveys in the northeastern Irish Sea.

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1. INTRODUCTION

As part of the environmental monitoring required under the conditions of the Ormonde Offshore Wind Farm Marine Licence (L/2011/00201/10), Centre for Marine and Coastal Studies Ltd (CMACS) have been commissioned by RPS Group plc on behalf of Vattenfall Wind Power Ltd, to carry out vessel-based transect surveys of sea birds in and around Ormonde Offshore Wind Farm (OOWF).

Condition 3.1.7 of the Ormonde Marine Licence specifies that ornithological monitoring must be carried out in line with Annex 2 of the Marine Licence, with the full specification for monitoring to be agreed separately with the Licensing Authority following consultation with Natural England. The specification for ornithological monitoring is presented in the Ormonde Environmental Monitoring Plan (EMP) (Ormonde Energy Limited, 2009), which was approved by the Licensing Authority following consultation with Natural England in April 2010.

Boat-based ornithological surveys have been carried out at the Ormonde site in order to address objective 1 of the EMP, in summary to determine whether there is change in bird distribution, use, abundance, behaviour and passage in relation to the wind farm site and its vicinity.

The EMP specified that surveys would record all bird species present, however, during the summer, including the late summer period, the focus of the surveys would be on Manx shearwater *Puffinus puffinus* and lesser black-backed gulls *Larus fuscus* in particular, with surveys to be carried out in May, July, August and September. Manx shearwater and lesser black-backed gull are on the amber list of species of conservation concern (Eaton *et al.*, 2009).

Aerial surveys were carried out over the winter period to monitor other key species identified in the Marine Licence, and are reported separately.

Pre-construction boat-based bird surveys were carried out in summer 2008 and in May 2009, with during-construction surveys taking place between 2010 and 2011, and three years of post-construction surveys completed between 2012 and 2014.

The Ormonde OWF is located in the Irish Sea, approximately 9km from the Duddon Estuary Special Protection Area (SPA), 12km from the Morecambe Bay SPA and 17km from the Liverpool Bay SPA, which are important for many species of wader and wildfowl. The Irish Sea, generally, is also an important area for breeding Manx Shearwaters, which nest in western Scotland, North Wales, the Isle of Man and Northern Ireland and forage throughout the Irish Sea. Walney Island lies inshore of the wind farm and is important for nesting gulls in the summer, supporting one fifth of the Great Britain breeding population of lesser black-backed gulls.

OOWF is a 150 MW development of thirty 5 MW wind turbines and an offshore substation. Construction began in April 2010 and was completed by early autumn 2011 with the wind farm

becoming fully operational in February 2012. Construction activities were on the following timeline:

2010

- Foundation piling took place from April until July;
- Installation of substation and turbine jackets took place from June to November.

2011

- Turbine installation took place from March to July, though the installation vessel remained on site until August;
- Export cable installation took place from January to March, with rock dumping in May and, cable burial on some sections during September and October;
- Inter-array cable installation took place from March to June, with burial on some sections carried out during November and December;
- Wind farm commissioning took place throughout the year and was completed in 2012.

This report presents results of the final boat-based ornithological surveys undertaken in and around OOWF in May, July, August and September of 2014. The results of the 2014 survey are presented first, followed by detailed comparisons with previous surveys.

2. METHODS

2.1 2014 Surveys

All of the 2014 surveys were carried out along strip-band transects (Figure 1) from the survey vessel, *Fleur de Lys* (Figure 2), where a pair of surveyors were observing from an elevated platform. Survey effort was divided evenly between wind farm and reference areas.

Survey methods complied with the guidelines of Camphuysen *et al*. (2004) as follows:

- All observations were divided by distance into the following bands; 0-50m, 50-100m, 100-200m, 200-300m and 300+m;
- Flight height of birds was registered in the following elevation intervals: sea surface, 1-30m, 30-140m and 140m+;
- Predetermined transects were followed at 10 knots (approximately 18km/hr);
- A pair of surveyors worked together from a platform that ensured eye-height was above five metres and with shared 360^{o} field of view;
- Survey time intervals were one to five minutes;
- No observations were made over sea state 5 as registering birds becomes severely impaired owing to vessel movement and birds on the sea being obscured by waves;
- Weather conditions, including sea state, wind speed and wind direction, were noted throughout the survey; and,
- Snap counts were taken every minute (equating to every 300m at 10 knots).

Observers were trained to ESAS and JNCC MMO standards and all possessed multiple years of experience of ornithological surveys in the north east Irish Sea. Each observer was equipped with a pair of binoculars and a digital dictaphone for recording bird sightings. Three surveyors were used with two working and one resting in shifts, which helped to reduce fatigue on the longer transects and improved data quality. Surveyors also swapped sides of the vessel at the start of each shift to reduce surveyor bias. A hand-held GPS with sub-five metre accuracy was switched on at the surveyors' position for the duration of the survey, which recorded their position every 12 seconds and was synchronised to the on board surveyors' time pieces. At the end of each survey, the GPS was downloaded and the coordinates matched by time to records of birds to provide a position for each sighting.

Records were taken of time of observation, number of individuals, age class, distance from vessel, flight direction and height where appropriate, and behaviour, including association with vessels or offshore platforms. Birds were recorded to species where practicable but were identified as accurately as possible (e.g. 'tern sp.') when birds were distant or in poor light conditions. Any cetaceans, seals or other marine mega fauna observed during the surveys were also recorded.

In 2011, taking records of any marine mammals sighted in the survey area was added to the scope of works. However, observers had been taking such records incidentally since the surveys began so there was good continuity of records throughout the monitoring period.

Surveys were planned and successfully undertaken in May, July, August and September 2014, with one day of survey per month.

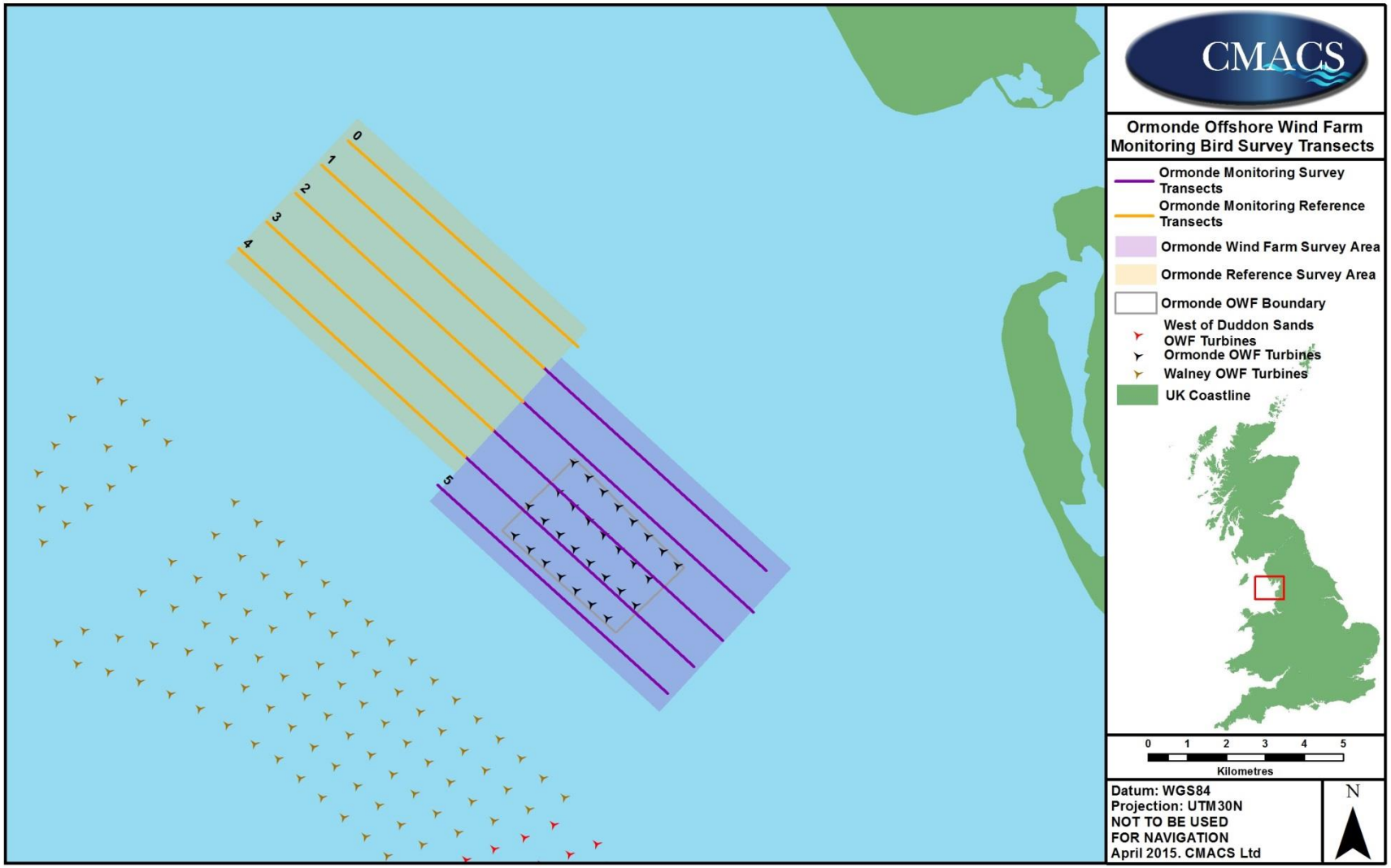


Figure 1. Transect lines followed by *Fleur de Lys* for Ormonde OWF 2014 bird survey.

Figure 2. Survey vessel *Fleur de Lys*

2.2 2008-2014 surveys

The surveys from 2009 onwards were carried out on the same transect lines (five wind farm and five reference lines) in all years of survey and the same methodology was also used in all years, providing consistency of effort in each survey.

In 2008, there were six wind farm lines and three references lines (**Figure 3**), but these nine lines formed the template for the 2009-2014 surveys and therefore the data is comparable as the lines were the same (**Figure 4**). Surveys in 2008 were carried out on the vessel *RV Aora*.

In 2009 and 2010, the surveys were mainly carried out on the vessel *Halcyon Days* (**Figure 5**) with one survey carried out on the *EMS Vulcan* CTV provided by DONG at Barrow when *Halcyon Days* was not available. Both vessels had a platform that provided surveyor eye height that was at least five metres above sea level as per the guidelines. In 2011, surveys were carried out on the *Seaguard* as the seabird monitoring programme from 2011 onwards, which included other wind farms in the area, required a vessel with a greater endurance than the *Halcyon Days* could provide.

The *Fleur de Lys* was used for the first time in 2012 (and all surveys thereafter) as the *Seaguard* was sold by the vessel operator but offered the *Fleur de Lys* as a vessel of equivalent sea-worthiness.

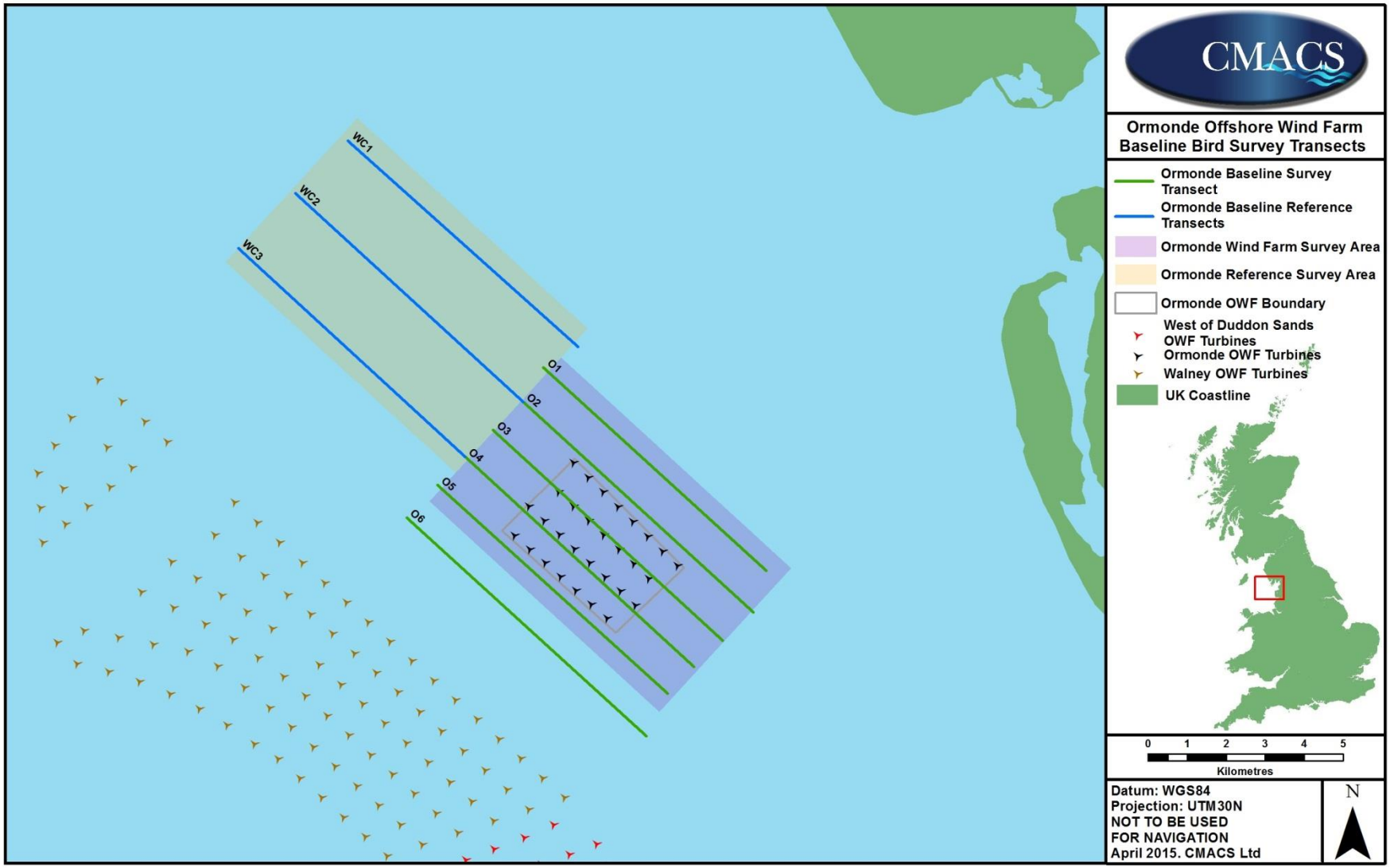


Figure 3. Baseline transects followed during the 2008 surveys.

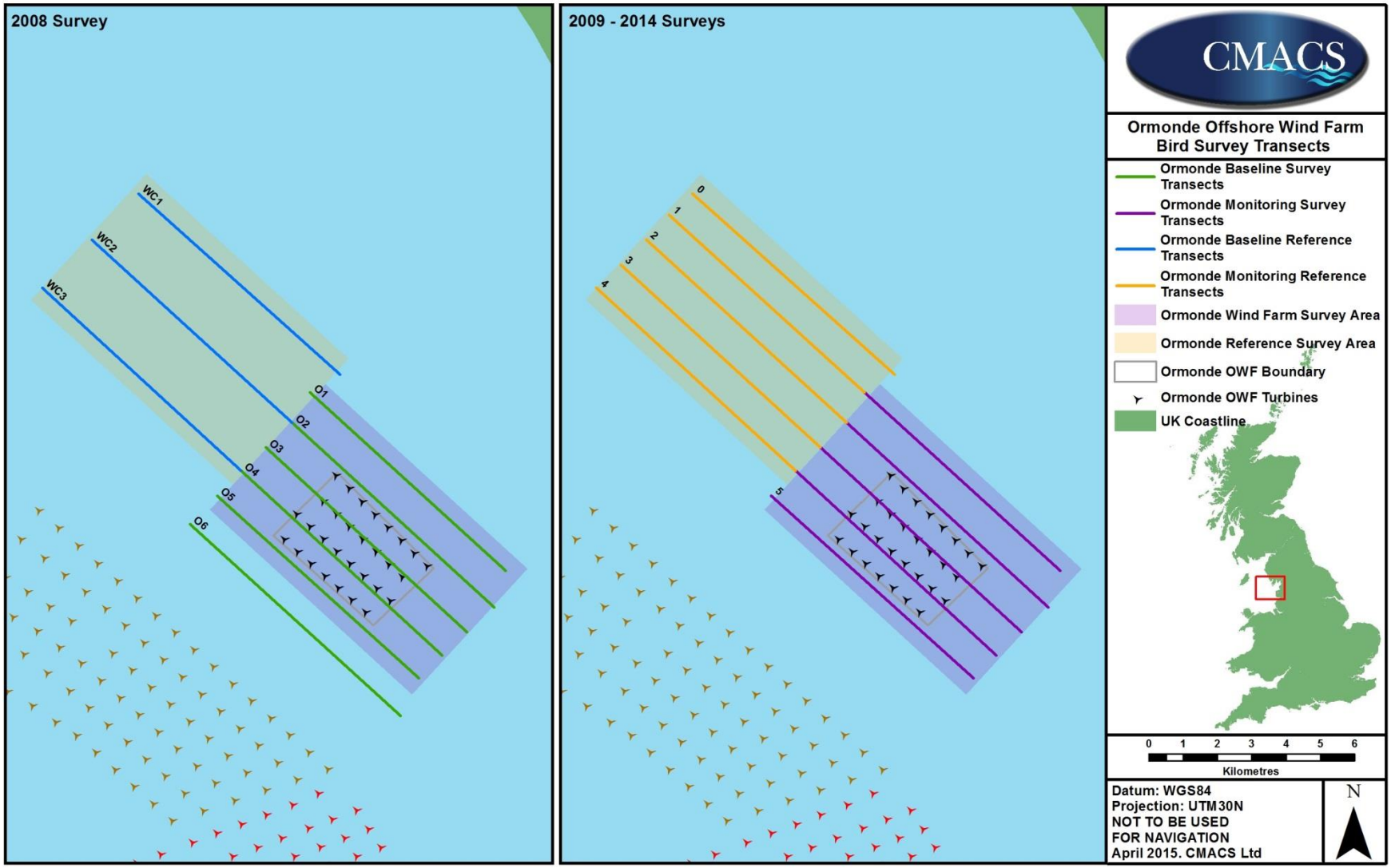


Figure 4. 2008 baseline transects in relation to transects used 2009-14. Note that the data from transect 6 was omitted from the between phase comparisons.

Figure 5. Survey vessels used 2008-2011. *RV Aora* (top left), *Halcyon Days* (top right), *EMS Vulcan* (bottom left) and *Seaguard* (bottom right).

2.3 Initial analysis

Raw counts of the total number of birds and of the top five most abundant species are presented as bar charts comparing the reference area to the wind farm area, as are comparisons between reference and wind farm area of the number of birds in each survey year.

Plots are provided of the position of each sighting in the 2014 survey but also by month for 2008 to 2014, but with transect 6 removed from the 2008 data to provide better consistency with the 2009-14 data.

Presence and abundance of the species of interest is discussed in the results but as Manx shearwater and lesser black-backed gull were the only birds of interest that were recorded in any numbers (see results section), only these species were investigated further with maps of estimated bird density. These were produced by overlaying the survey area with a grid of kilometre squares, then each square was given an identity (e.g. R0_1 meaning the first square on reference transect zero) and sightings of Manx shearwater or lesser black-backed gull were numbered and then plotted onto the map (each year's records separately) so that sightings could be assigned to a particular square. The number of birds from each sighting in each square was then summed and multiplied by a factor of 1.67 (as the number of birds recorded

was from a 0.6 km-wide transect) to estimate the number of birds per square kilometre. There were four baseline phase surveys, eight construction phase surveys and twelve post-construction phase surveys and therefore estimated densities from the construction phase and post-construction phase were divided by 2 and by 3 respectively to correct for the differences in survey effort.

Bird data was distance-corrected under the following assumptions:

a. All birds in flight up to 300m from the vessel were recorded;
b. All birds in distance bands 'a' and 'b' (i.e. up to 100m from the boat) were recorded.

Based on these two assumptions, therefore, detection of birds in bands 'c' and 'd' were lower than in bands 'a' and 'b', with the requirement for correction. The correction factor was calculated with the following formula:

$$\text{Correction factor} = \frac{(a+b)*3}{(a+b+c+d)}$$

Any correction factor of greater than 1 was applied to the bird data, any correction factor of less than one was assumed to indicate that detection of the species was equal out to 300m and no correction was required.

2.4 Statistical analysis

The aim of the statistical analysis of the bird data was to determine whether or not there had been any significant change in the abundance of birds in the Ormonde wind farm area between the pre-construction phase, the construction phase and the post-construction phase.

Statistical analysis was carried out on survey data from the following months and years[1]:

- May 2009;
- May, July, August & September 2010;
- May, July, August & September 2011;
- May, July, August & September 2012;
- May, July, August & September 2013; and,
- May, July, August & September 2014.

These survey months and years were allocated to the following phases:

- Pre-construction: May 2009;
- During-construction: May 2010 to September 2011; and,
- Post-construction: May 2012 to September 2014.

In the analysis, comparisons were made between these three phases to examine for differences in bird abundance in the three different periods of activity at the wind farm site.

[1] For consistency with previous reports, 2008 data were not included in statistical analysis.

Records of birds in flight and those of birds on the water were grouped together for the purposes of the analysis and only those birds recorded from within 300m of the vessel (i.e. within the transect) were included.

For the purposes of the comparisons, each transect was treated as an independent sampling unit and it is for this reason that only those birds within the 300m transect were included in the analysis. Certain birds (e.g. gannets and large gulls) can be seen in flight on clear days at over a kilometre from the vessel. Since transects are spaced a kilometre apart (see **Figure 1**), 'cross-transect' records are possible and need to be eliminated from the data prior to analysis. In each survey, therefore, there were ten independent sampling units; five in the reference area and five in the wind farm area (see **Figure 1**).

Bird counts of each species on each transect were analysed using a generalised linear model testing the two-way interaction between the phase of construction and the survey areas (i.e. reference and wind farm).

Different applications of this test were generated to answer the following questions:

1. Are there any differences between the number of birds recorded from the reference area and the wind farm area in each survey year?
2. Is there a difference in the total number of birds recorded between monitoring phases (pre, during and post construction)?
3. Are there any particular species of bird that have decreased or increased in any of the monitoring phases?
4. Are there any differences in the proportions of birds in flight and those on the sea surface between the monitoring phases?

A generalised linear model is a method for analysing the relationship between variables in situations where the data do not conform to a normal distribution. Owing to the fact that data points for the bird surveys were distributed in both space and time, a Poisson distribution was most appropriate for the analysis. As there is not a direct linear relationship between variables in a generalised linear model, a log link function was required and applied. The terms used in the model were 'visit' (i.e. date), 'transect', 'stage' (i.e. phase of construction), 'site' (reference and wind farm) and the interaction of 'stage' and 'site'. Statistical analyses were carried out in the program GLIM.

The differences in the number of birds in the wind farm between each monitoring phase were expressed as a ratio of counts between phases, using the data from the reference area as a comparison. This was calculated from a series of pairwise comparisons, which can be expressed as a 2x2 table, for example:

	Pre-construction	**During-construction**
Reference area	n_1	n_2
Wind farm area	n_3	n_4

Where *n* is the number of birds recorded in the specified area in the specified phase. A model fitted to these pairwise comparisons allows GLIM to estimate a ratio of birds between the factors as required with a confidence limit (see Appendix 3).

A ratio of 1 corresponds to no difference between factors while any ratio of less than 1 would indicate that one factor is lower than the other and a ratio greater than 1 that one factor is higher than the other. In simple terms, the test assumes that in the absence of the wind turbines, the wind farm area would have the same avian community and abundance as the reference area.

3. RESULTS

3.1 Overview of 2014 data

A total of 1,637 individual birds (raw counts) were recorded from the four surveys in 2014; 609 individual birds from wind farm transects and 1,028 individuals from the reference area. The greatest count was in July when 265 individuals were recorded in the wind farm and 724 in the reference area, the lowest count was in May from the reference area with 58 individuals.

A total of 21 distinct taxa were recorded from the entire Survey Area, 18 of which were identified to species and the remaining three to genus level or higher. Similar numbers of taxa were recorded in wind farm and reference areas (17 and 18 respectively).

Manx shearwaters *Puffinus puffinus* were by far the most abundant species recorded during the programme, but almost all were recorded in July, with markedly more from the reference area than the wind farm (Figure 6). Guillemots *Uria aalge* and lesser black-backed gulls *Larus fuscus*, were the next most abundant species respectively, although they were both recorded in all survey months, with more balanced numbers from different areas. Kittiwakes *Rissa tridactyla* were also abundant, although most were recorded within the wind farm in July. Common scoters *Melanitta nigra* and gannets *Morus bassanus* were reasonably numerous, but the former were almost all recorded within the wind farm in May whereas the latter were recorded in all survey months and both areas; albeit in lower numbers.

Species richness did not vary greatly throughout the year in either the wind farm or reference area, generally oscillating around approximately 10 species (see Appendix 1). There was no marked influx of migrating passerines (perching birds), which can occur at certain times of the year, but which is heavily influenced by prevailing meteorological conditions (i.e. whether the birds are forced to fly low rendering them more detectable). The majority of the avifauna recorded throughout the programme were true seabirds from groups such as auks, tubenoses, gulls, gannets, terns and sea ducks. A few species were observed migrating through the area but in very low numbers; three swallows (*Hirundo rustica*), one swift (*Apus apus*), one meadow pipit (*Anthus pratensis*) and one dunlin (*Calidris alpina*).

Figure 7 to Figure 10 show the position of the vessel (not bird location) for all bird registrations (both in flight and on the water) in the different survey months. It should be noted that each point

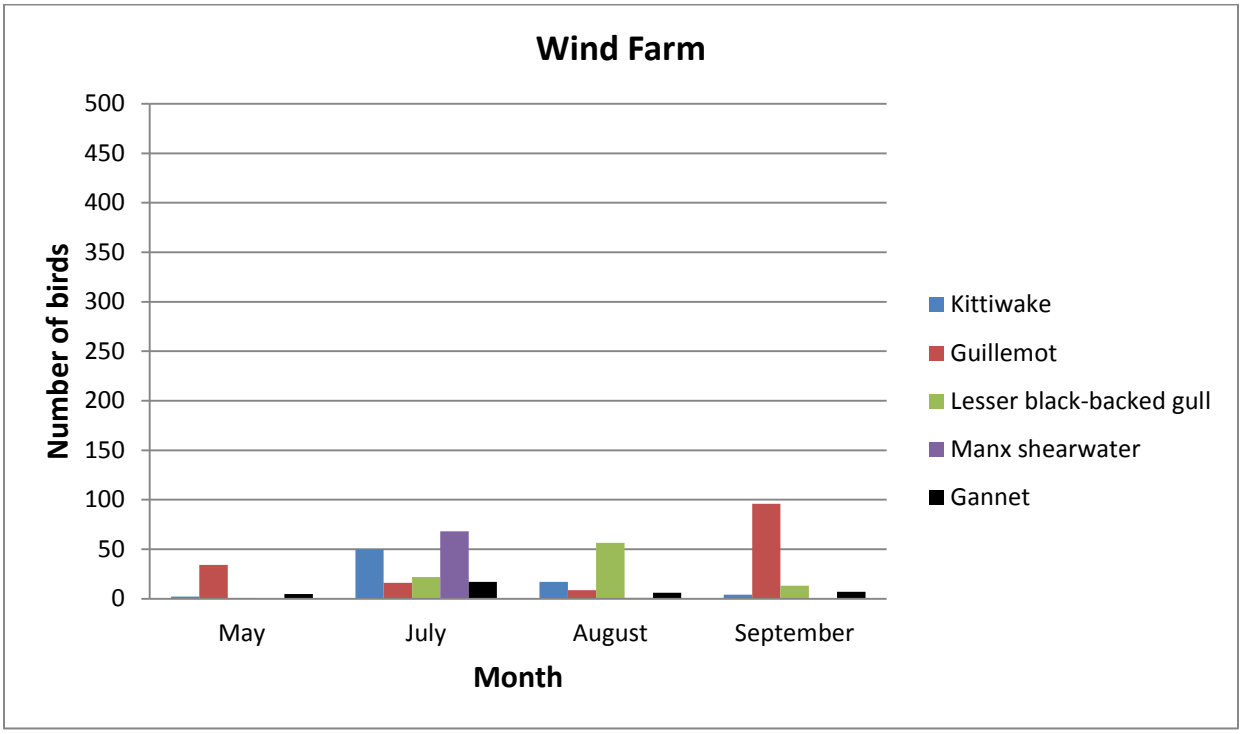
on the charts may represent a single or multiple birds. The maps help to visualise the larger number of records made in July (mainly owing to Manx shearwaters) There seems to be no clear overall preference of birds for either the wind farm or the reference area through time, along with a relatively even distribution across transects east to west (inshore to offshore).

Based upon raw abundance data, in May and August, sightings of birds on the water and birds in flight were relatively evenly distributed both within the wind farm and in the reference area. In July, approximately double the amount of birds were recorded in flight within the wind farm whereas the opposite was true in the reference area, while in September, birds on the water were double those in flight in both areas. There was no consistent trend in bird activity in each area across the surveys in the results. In addition, the results do not suggest that birds are only transiting the wind farm, but are likely to be resting and foraging within the area as well. There were a number of records of birds perching upon transition pieces of turbines and substations; predominantly gulls.

Numbers of birds recorded can sometimes be related in part to the sea conditions during surveys; for example, a higher sea state can make observations more difficult and therefore abundance appear depressed. However, sea state was generally moderate to good for all surveys in 2014. Sea and weather conditions are summarised in Table 1 below.

Table 1. Conditions during survey

Date	Wind Direction	Wind Force (Beaufort)	Sea State	Cloud Cover
16th May	Westerly	1 - 2	1 - 2	25 - 50%
12th July	Southerly then easterly	2 -3	1 - 3	100%
6th August	Southerly then westerly	3	2 – 3	90 – 100%
11th September	South-easterly	3	3	80 – 100%



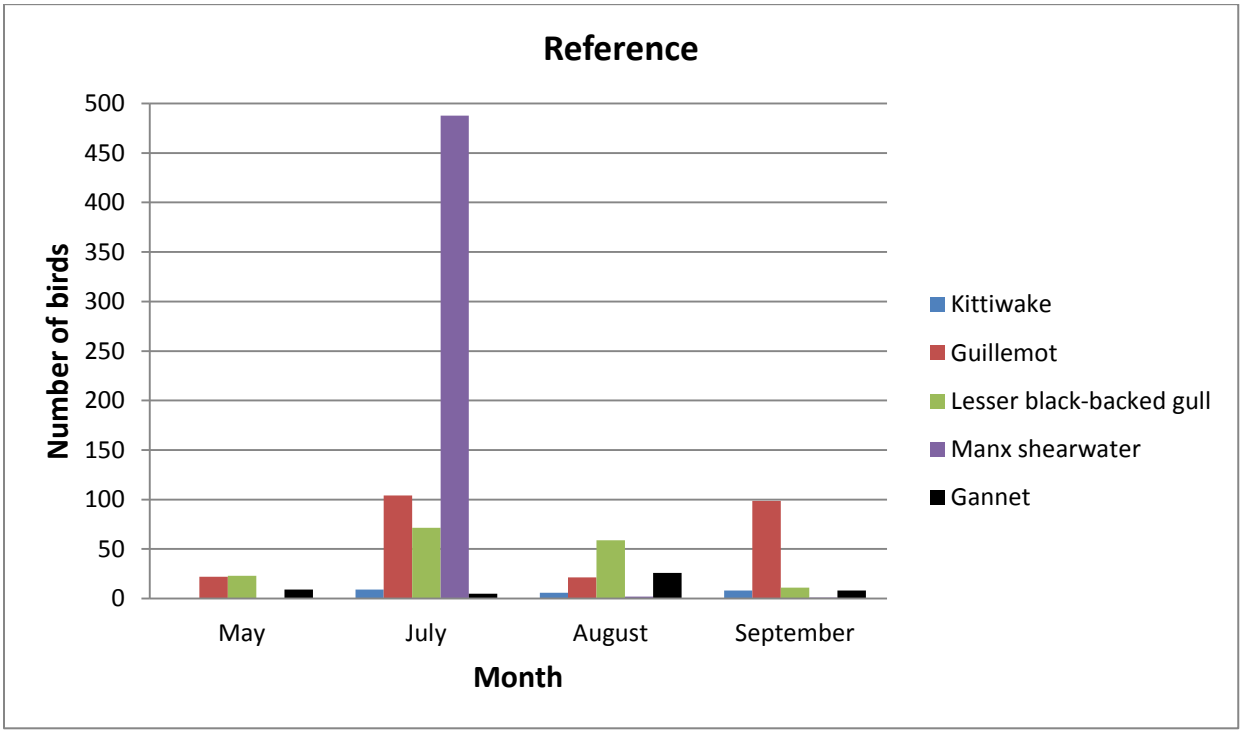


Figure 6. Numbers of the most abundant bird species in each month's survey during the Ormonde programme (data corrected for distance)

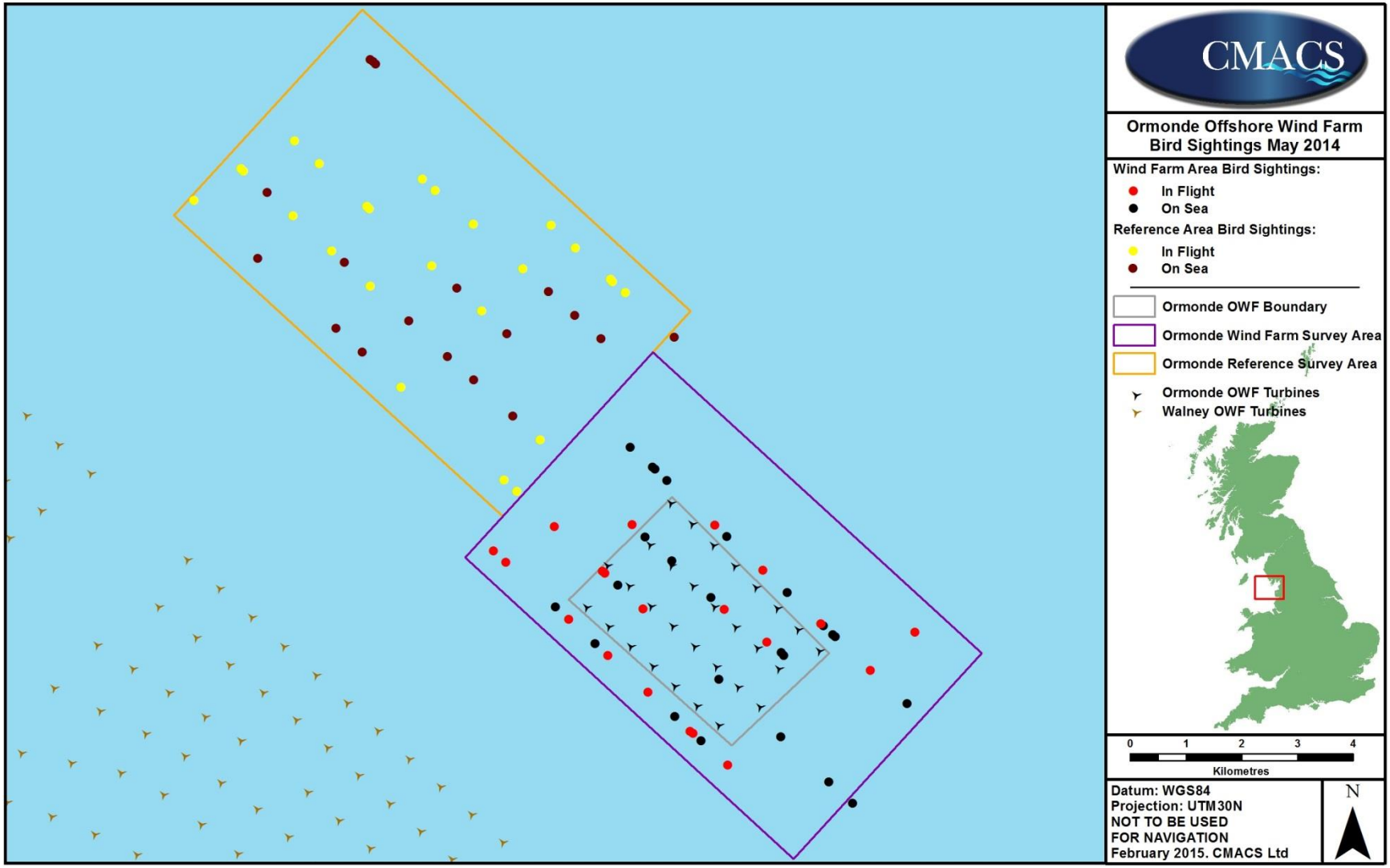


Figure 7. Position of survey vessel at time of bird records from Ormonde boat-based survey during May 2014

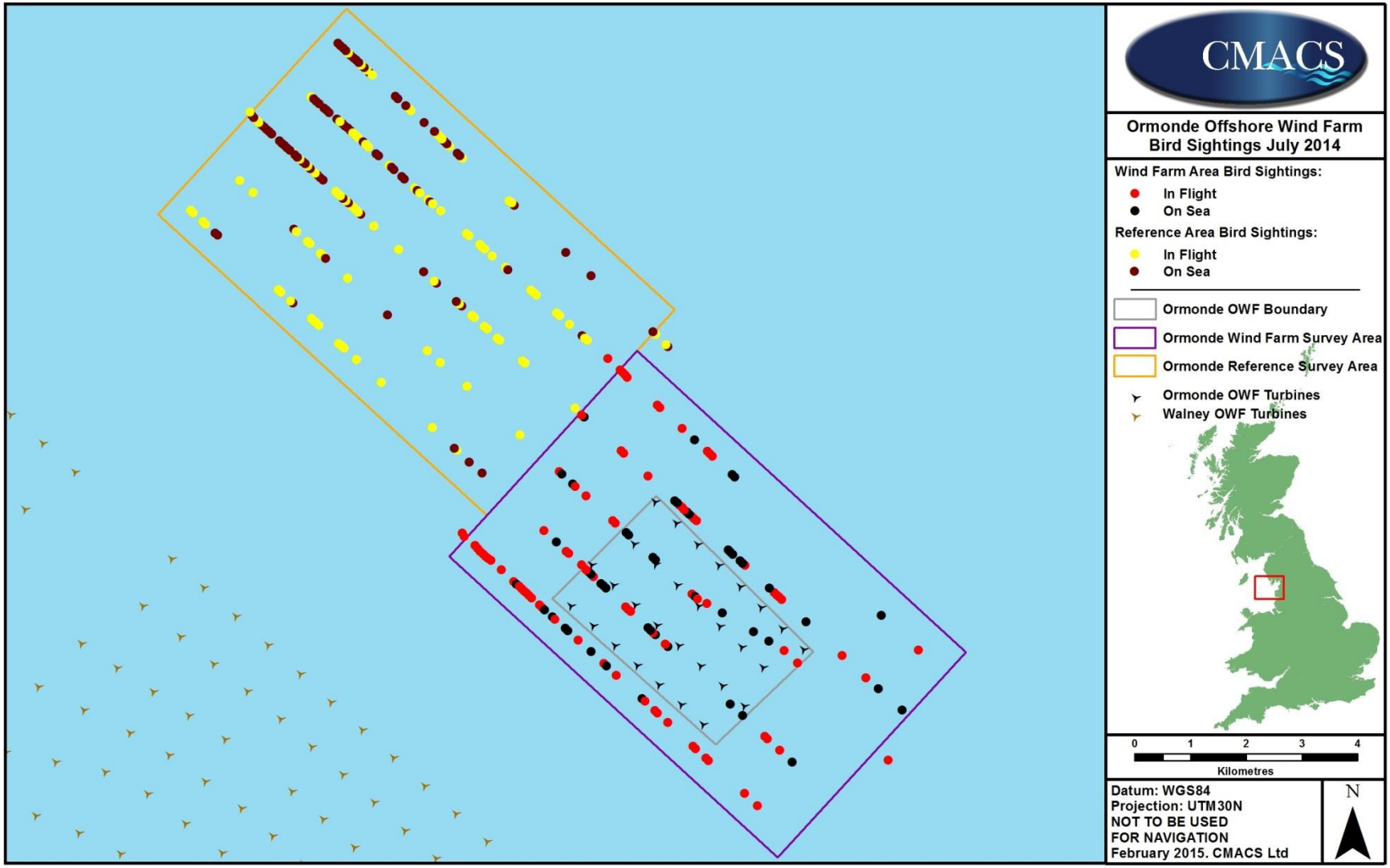


Figure 8. Position of survey vessel at time of bird records from Ormonde boat-based survey during July 2014

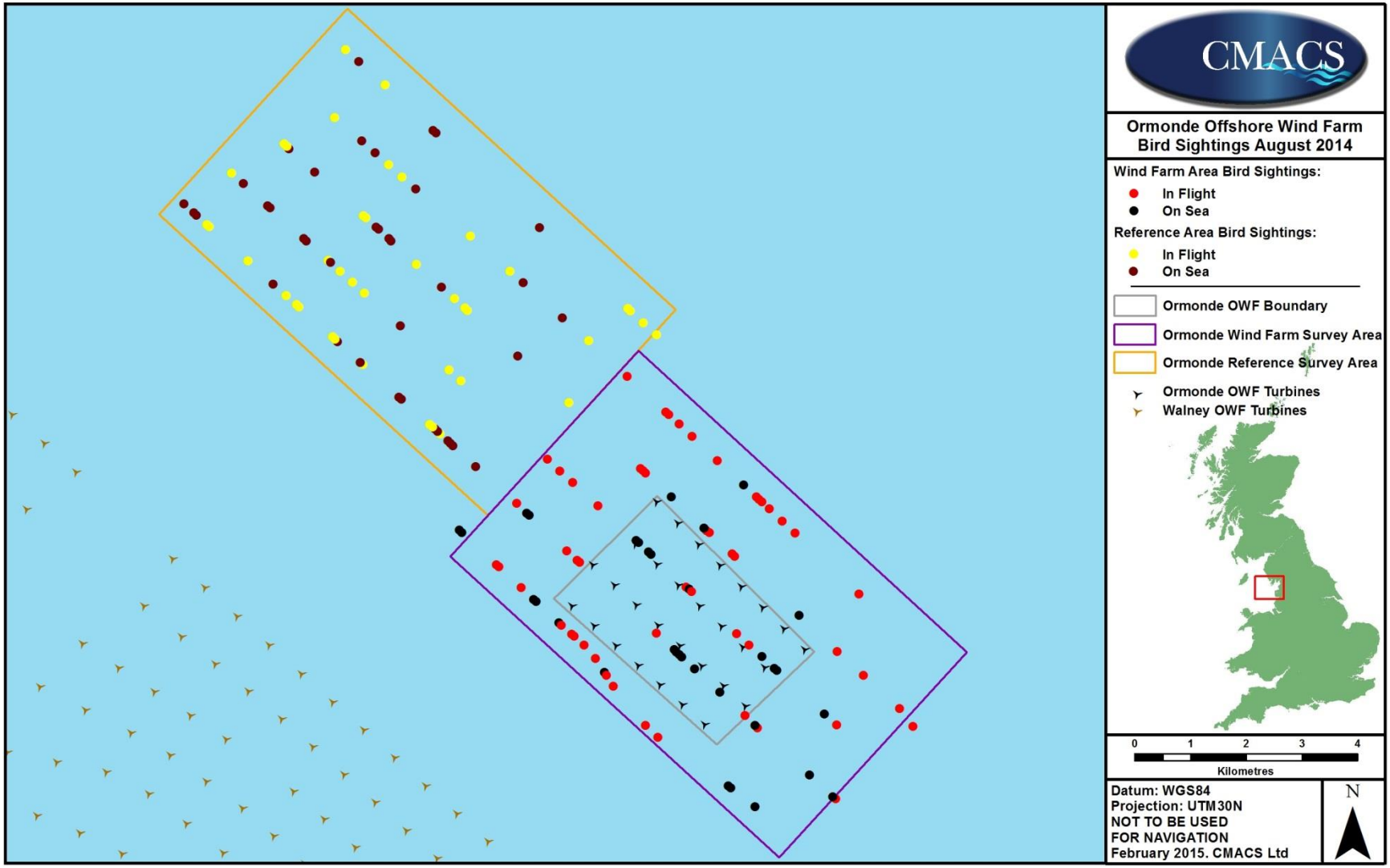


Figure 9. Position of survey vessel at time of bird records from Ormonde boat-based survey during August 2014

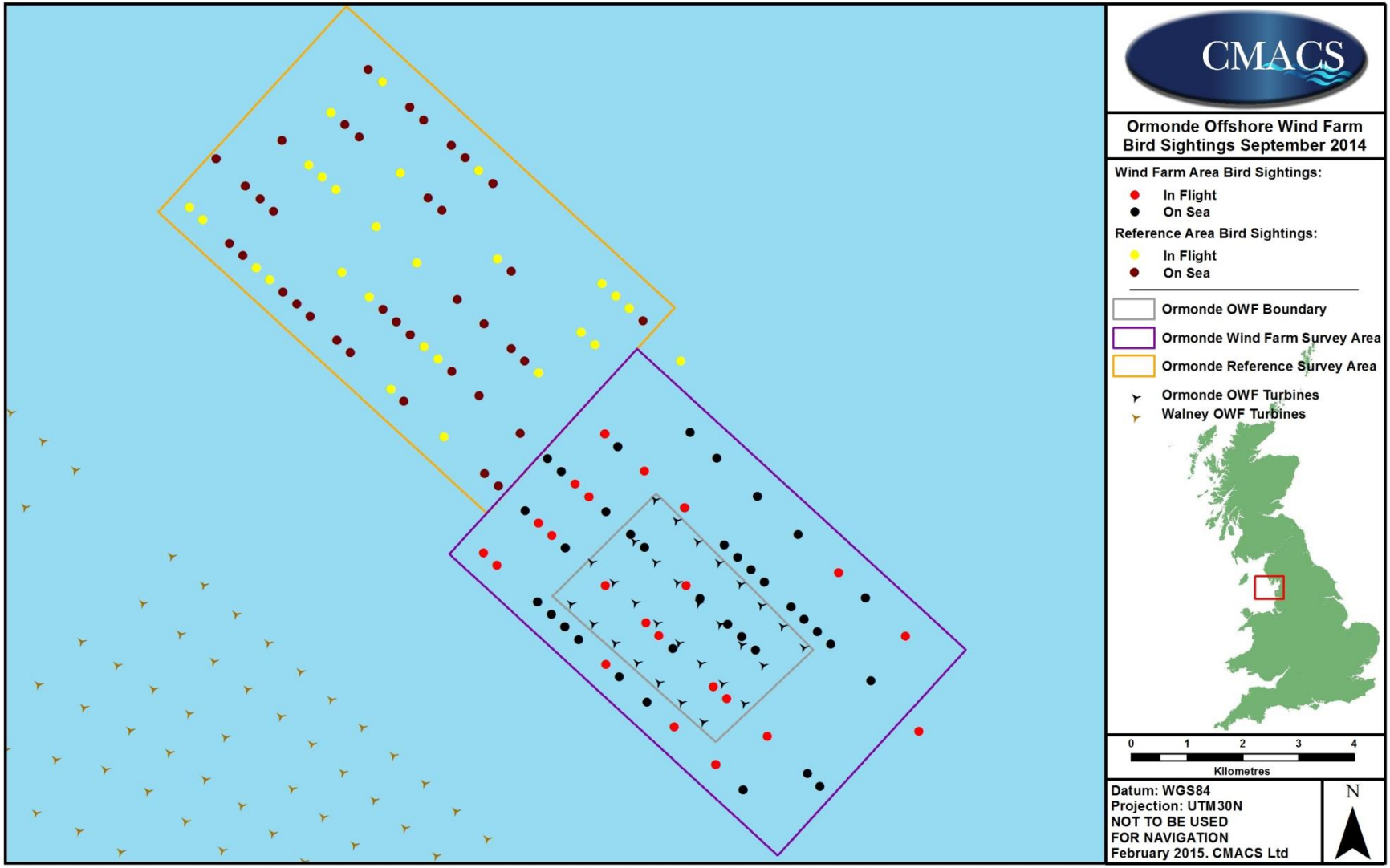


Figure 10. Position of survey vessel at time of bird records from Ormonde boat-based survey during September 2014

3.2 Species of interest

Manx shearwaters, *Puffinus puffinus,* were recorded in both the wind farm area and reference area, but almost exclusively in July in both instances. Greater numbers were recorded in the reference area than in the wind farm area (Figure 11) and the vast majority of records were of birds in flight.

Lesser black-backed gull *Larus fuscus* were recorded in all months in both parts of the survey area (Figure 12), with 50% greater overall abundance in the reference area. The highest abundances were recorded in July and August, most likely as a result of individuals dispersing from the breeding colony on Walney Island. This gull mainly moves inland for the winter and this migration may be a reason for the decrease in abundance in September.

Common scoter *Melanitta nigra* were also recorded (Figure 13), although predominantly within the wind farm area in May (52 individuals). No individuals were recorded in the wind farm area in other months and only a very low number were recorded in July and September within the reference area. All of the scoters were in flight and therefore likely to be transiting between aggregation sites such as the Solway Firth and Shell Flats.

No red throated diver *Gavia stellata* were recorded during the surveys.

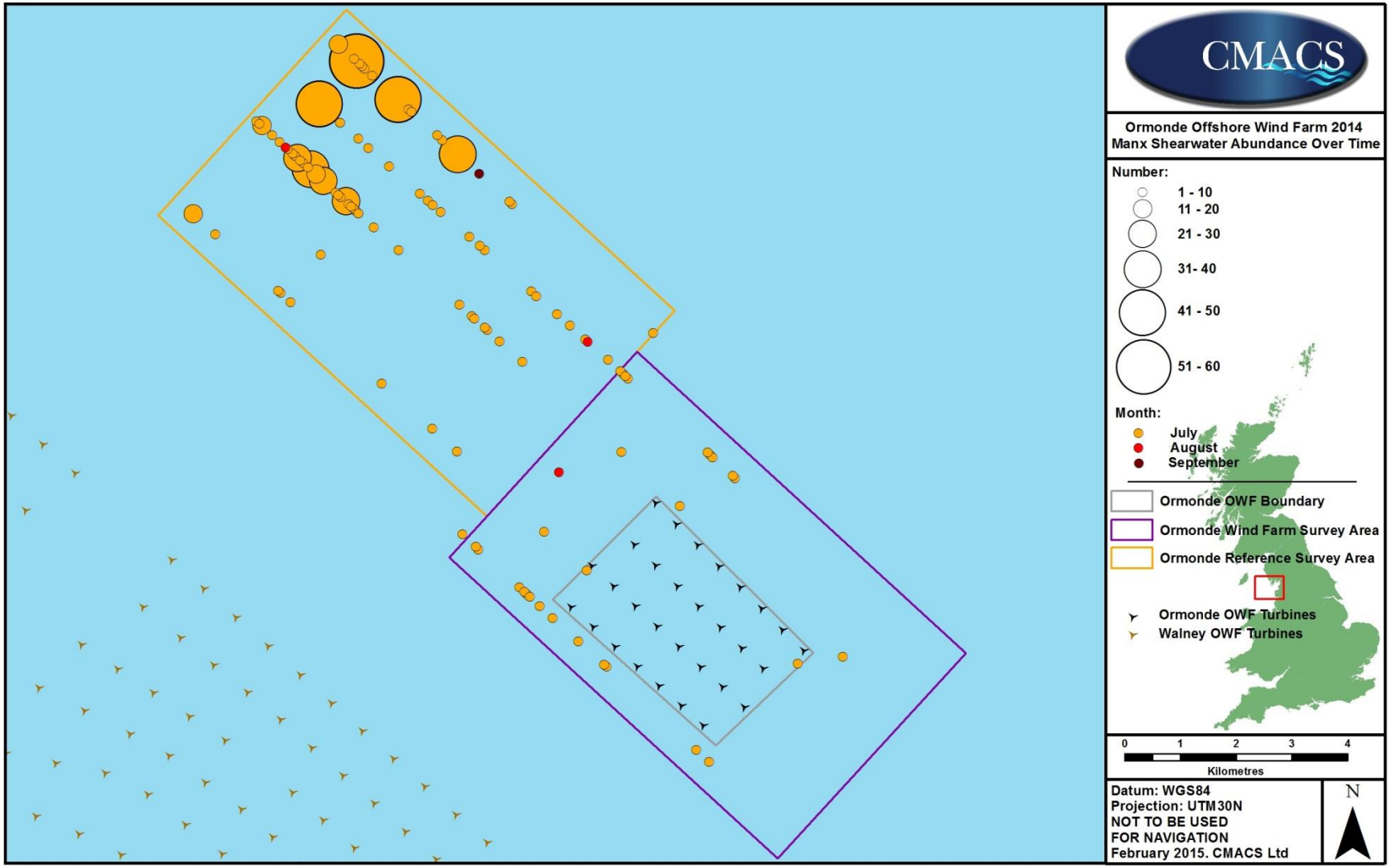


Figure 11. Distribution and abundance of Manx shearwaters in different months during 2014 programme

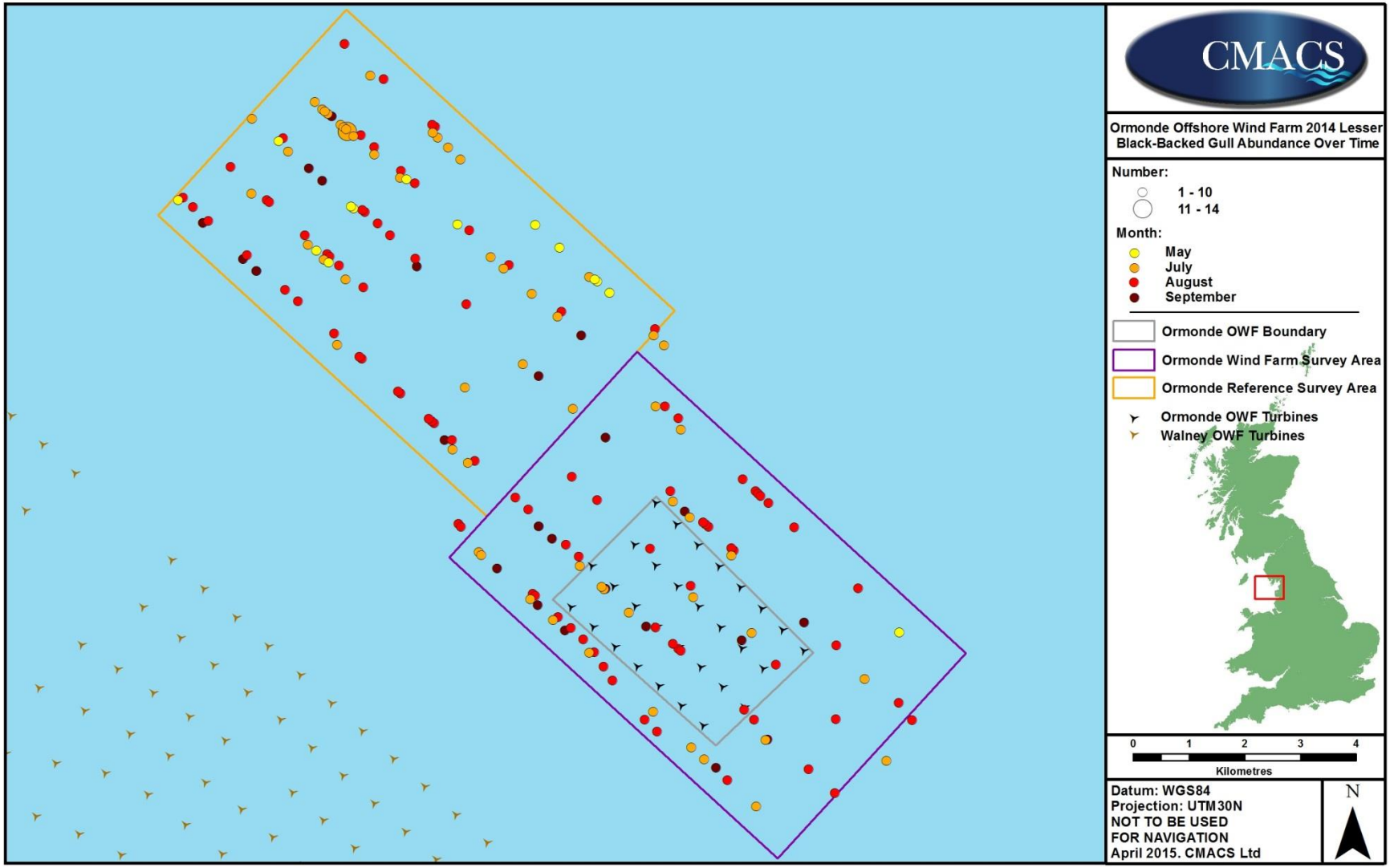


Figure 12. Distribution and abundance of lesser black-backed gull in different months during the 2014 programme.

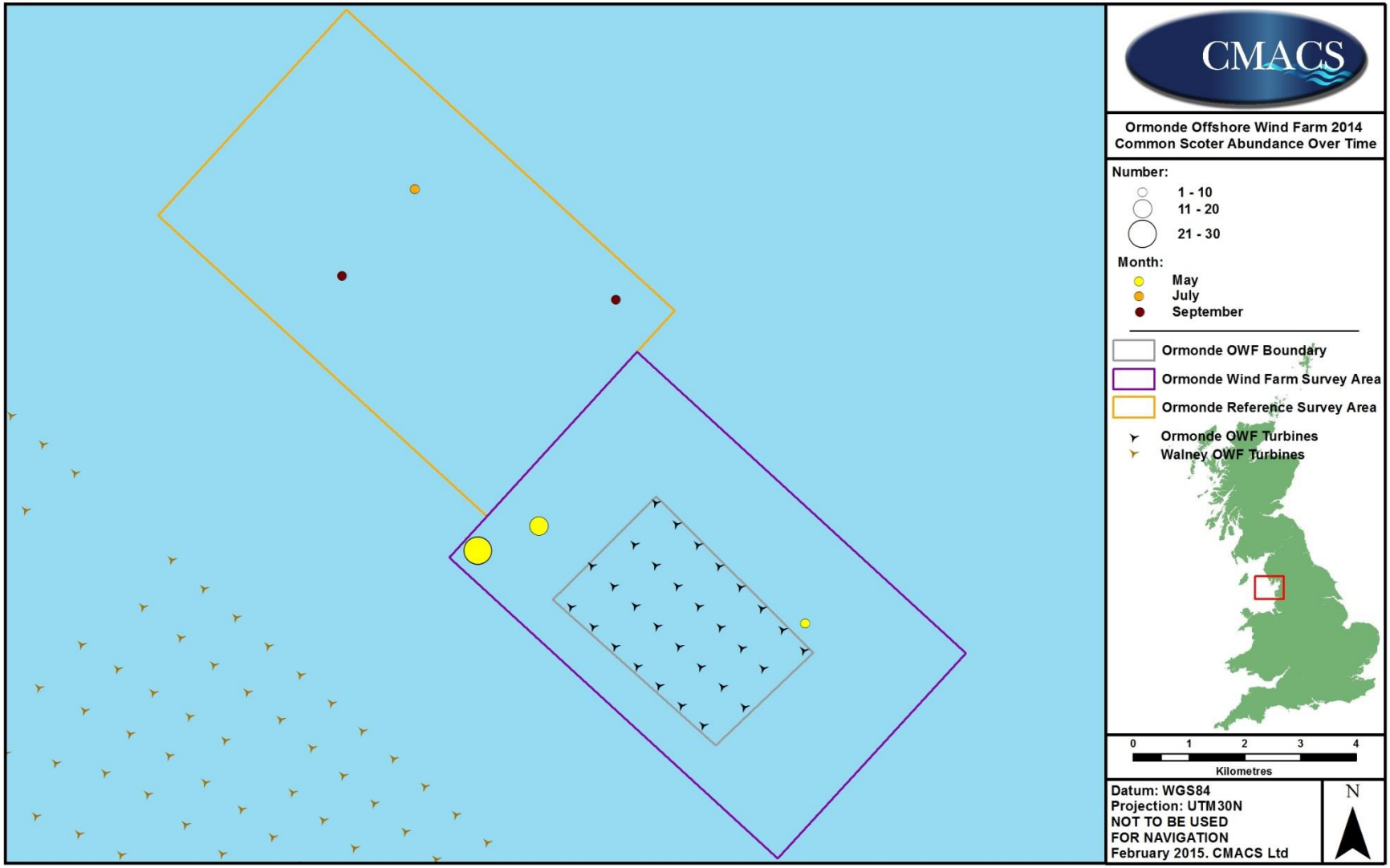


Figure 13. Distribution and abundance of common scoter in different months during the 2014 programme.

3.3 Marine mammals

The distribution and abundance of marine mammals recorded in 2014 are mapped in Figure 14 and listed in Appendix 2.

Grey seals *Halichoerus grypus* were recorded in every month of the survey programme in 2014, but in very low numbers, predominantly within or near the wind farm array.

Harbour porpoises *Phocoena phocoena* were also recorded during the 2014 programme, peaking in September, but with none observed in May. They did not seem to show any preference for a particular location, being present throughout the survey area.

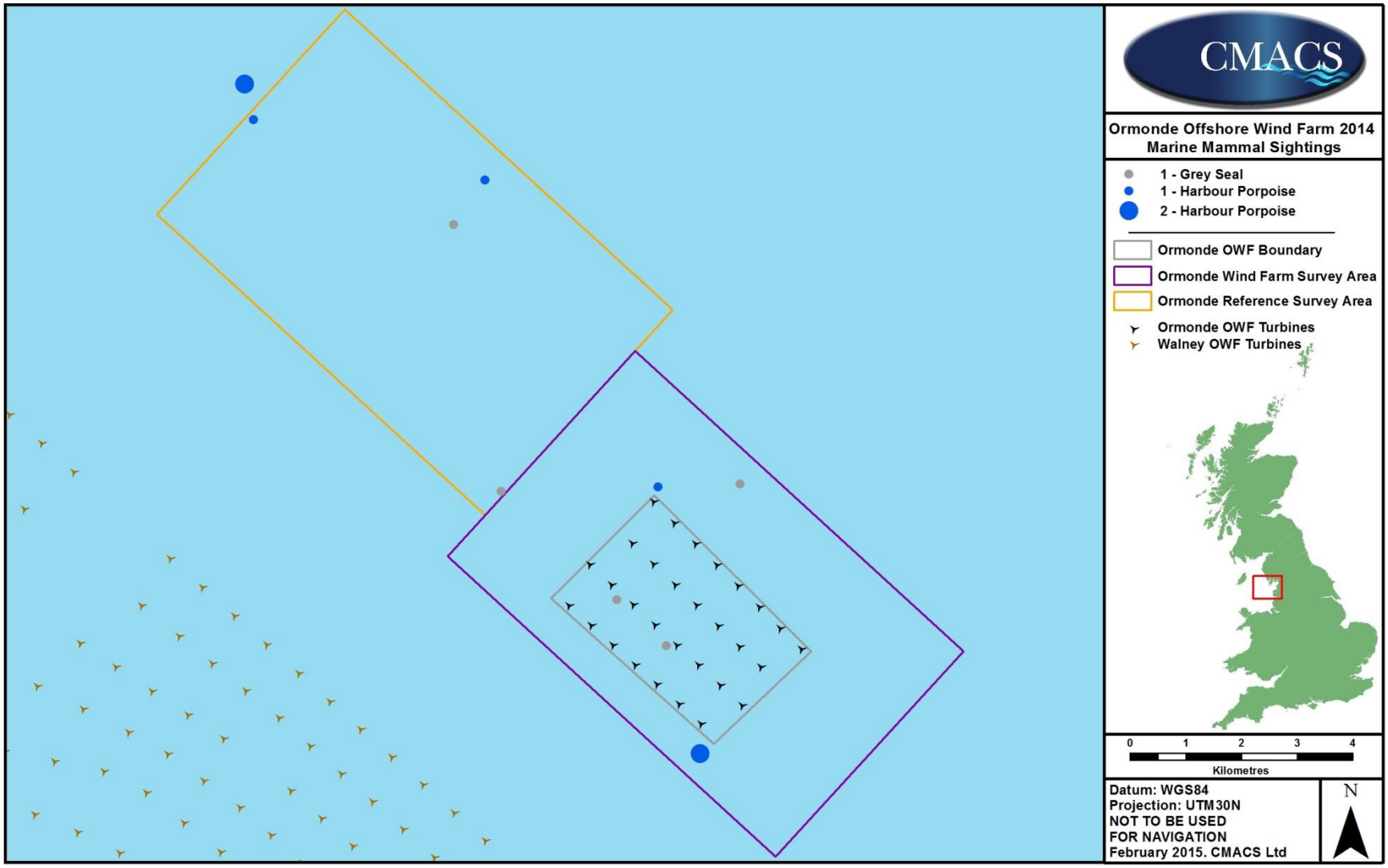


Figure 14. The distribution and abundance of marine mammals recorded across the survey area in 2014 (all months combined)

3.4 Comparison 2008 to 2014

OVERVIEW

An initial comparison of sightings between years is provided below. The queries set out in the **Error! Reference source not found.** section (0) are then addressed individually.

- May surveys (Figure 15): The tendency for fewer sightings to be made in both the wind farm area and the reference area from 2011 (late during-construction) appears to have continued in 2014, with no recovery suggested;
- July surveys (Figure 16): The increased numbers of sightings made in 2013 does not appear to have continued in 2014, with fewer sightings in both wind farm and reference areas, but not as few as in 2008 and 2011;
- August surveys (Figure 17): Numbers of sightings in 2014 are similar to those recorded in 2013. Therefore, the recovery from low numbers in 2011 remains, but has not continued to return to the higher 2010 figures; and
- September surveys (Figure 17): There were a greater number of records in all construction years and post-construction years compared to the baseline. Following a decrease in sightings (compared to 2010) in 2011, particularly in the wind farm area that was a common feature of all surveys in that year, numbers recovered to 2010 levels in 2012 and 2013. However, in 2014, numbers have decreased again, this time both within the array area and the reference area.

Figure 15 suggests that there were relatively high numbers of birds in May in the 2009 baseline and in the first year of construction but then decreased in all years thereafter. In contrast, Figure 16 to Figure **18** do not show any obvious trend between years (or construction phases) in the July, August and September surveys. Low numbers in the 2008 baseline were followed by greatly increased numbers in the 2010 construction year followed by a decrease again in the 2011 construction year.

Low numbers of records in 2011 may have been owing to the erection of the turbines in this year (i.e. the creation of a potential barrier or disturbance to flying birds) but the 2008 baseline data suggests that natural variability may also be a factor.

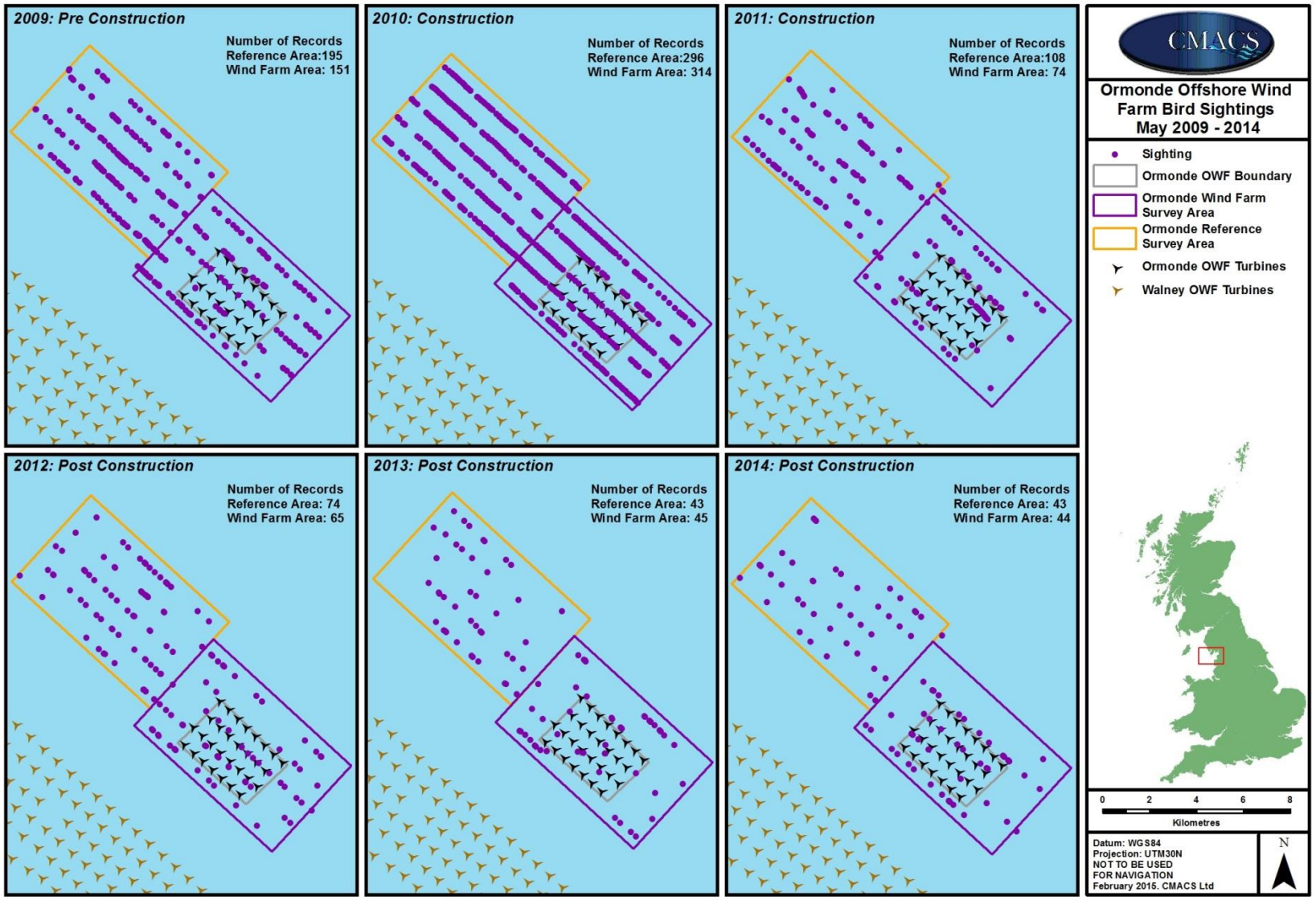


Figure 15. Position of survey vessel at time of bird records from Ormonde boat-based survey during May 2009 – 2014.

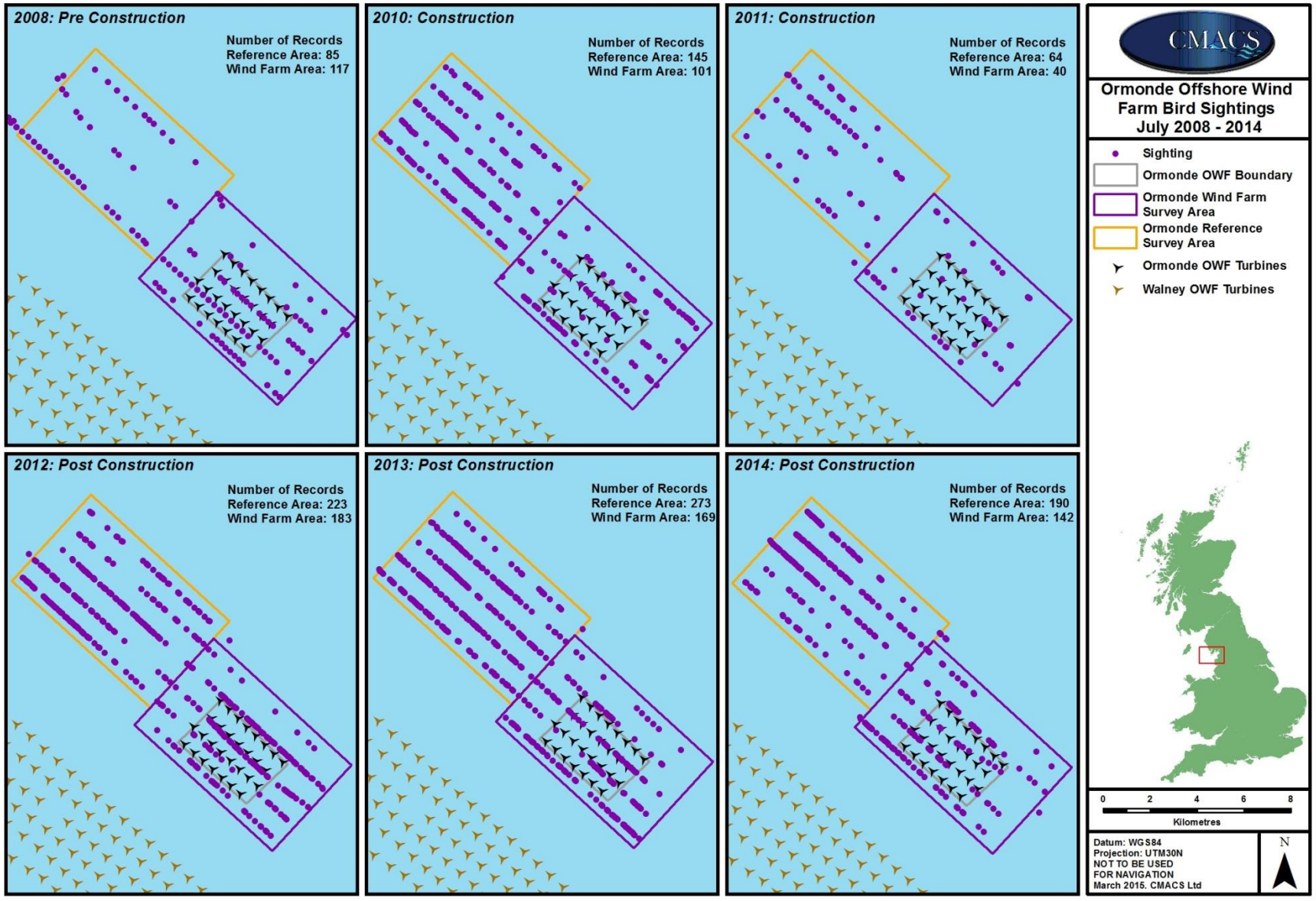


Figure 16. Position of survey vessel at time of bird records from Ormonde boat-based survey during July 2008 – 2014.

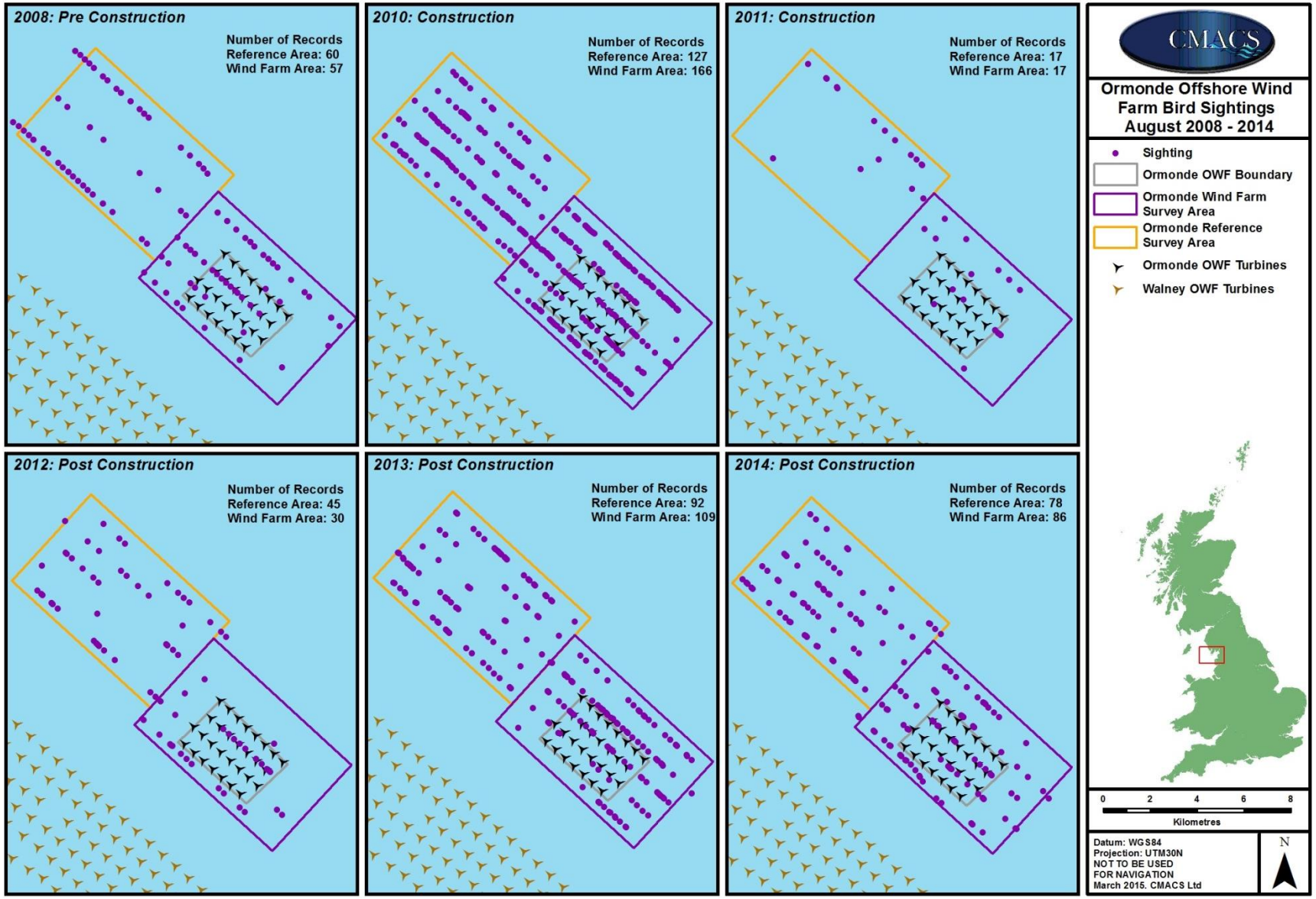


Figure 17. Position of survey vessel at time of bird records from Ormonde boat-based survey during August 2008 – 2014.

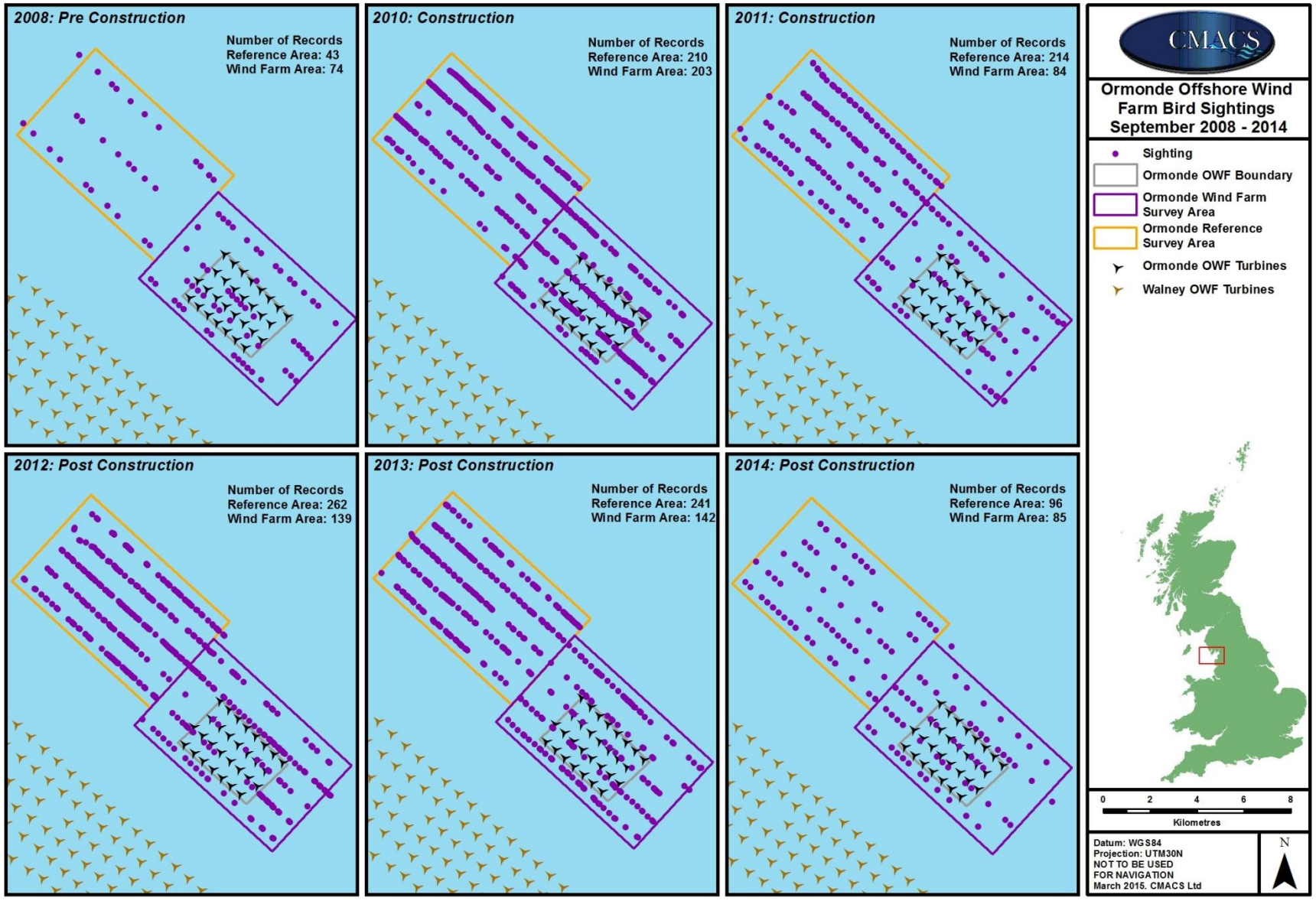


Figure 18. Position of survey vessel at time of bird records from Ormonde boat-based survey during September 2008 – 2014.

SPECIES OF INTEREST (2008-2014)

Manx shearwater

The map of abundance of Manx shearwater (Figure 19), suggests that there was generally a 'preference' (2010 excepted) for the reference area, even before construction began on the turbine array. This was true not only of the number of sightings but also the number of birds in each record. The map of bird density (Figure 20) mirrors this trend and also shows the sharp decline within and near the wind farm in 2011, but with partial recovery from 2012 onwards. There was no obvious decline in the reference area in any year.

Lesser black-backed gull

Sightings of lesser black-backed gull and the number of birds in each record are presented in Figure 21, which does not reveal any obvious trends with regard to the different construction phases. In 2009, sightings were more often of small groups of birds whereas records of singletons predominated in later surveys. From 2010 to 2013, there does appear to be a bias of sightings and numbers of birds towards the wind farm area and, in particular the turbine array, but this trend does not continue into 2014.

The relative densities of lesser black-backed gull between years are displayed in Figure 22, which shows a moderately even distribution of birds over the survey area but generally decreasing density with time. The previously described bias towards the array area can also be seen in Figure 22.

Common scoter

Only 22 sightings were made of common scoter over the seven years of monitoring with four to six sightings in each of 2008, 2012, 2013 and 2014 (Figure 23). Just under half of the observations were made in the wind farm area, none of which were within the turbine array, but inferences regarding the effect of the wind farm cannot be made confidently owing to the low number of records.

Red-throated diver

No red-throated diver were recorded in the surveys.

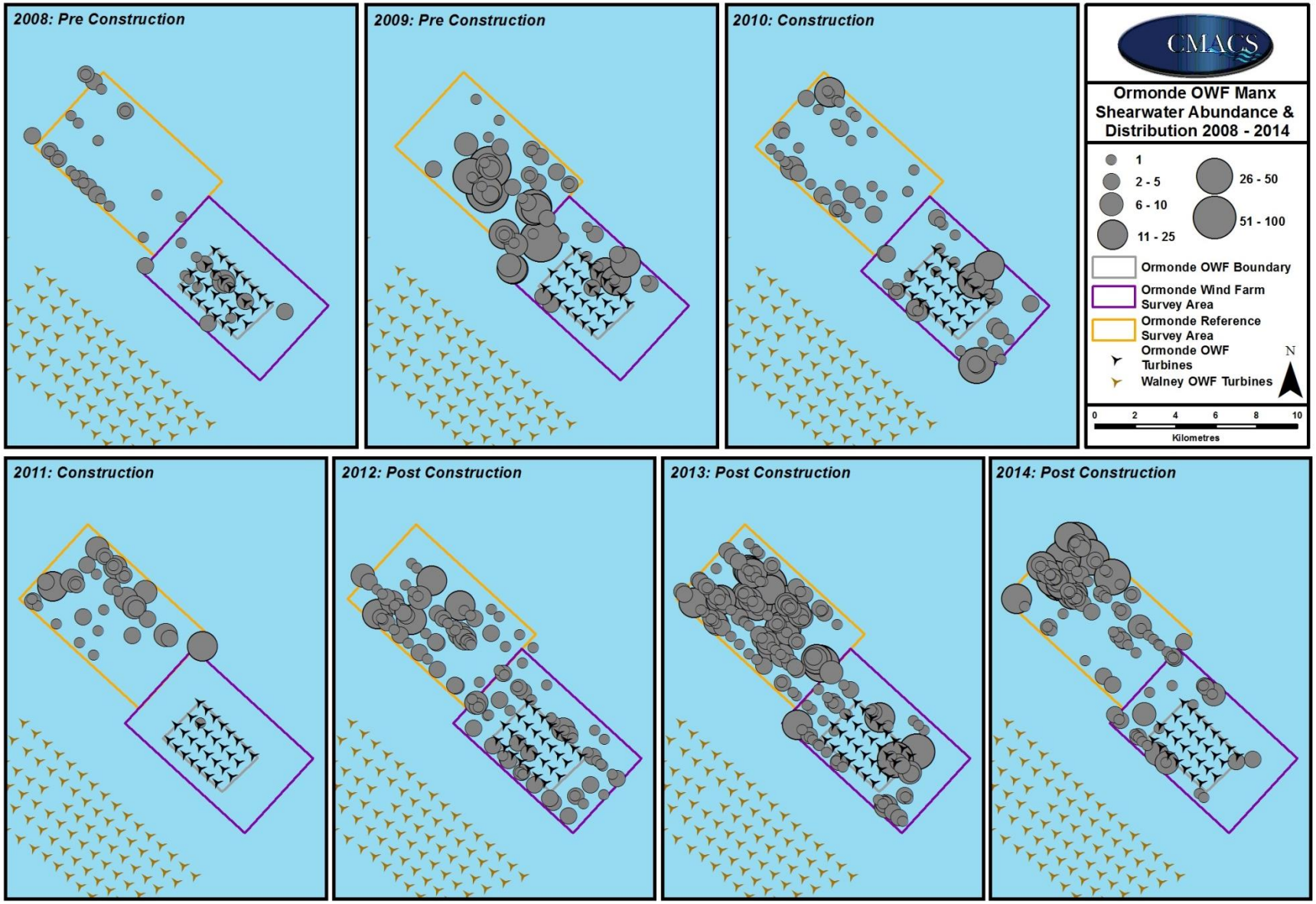


Figure 19. Distribution and abundance of Manx shearwater on Ormonde survey transects from 2008 to 2014

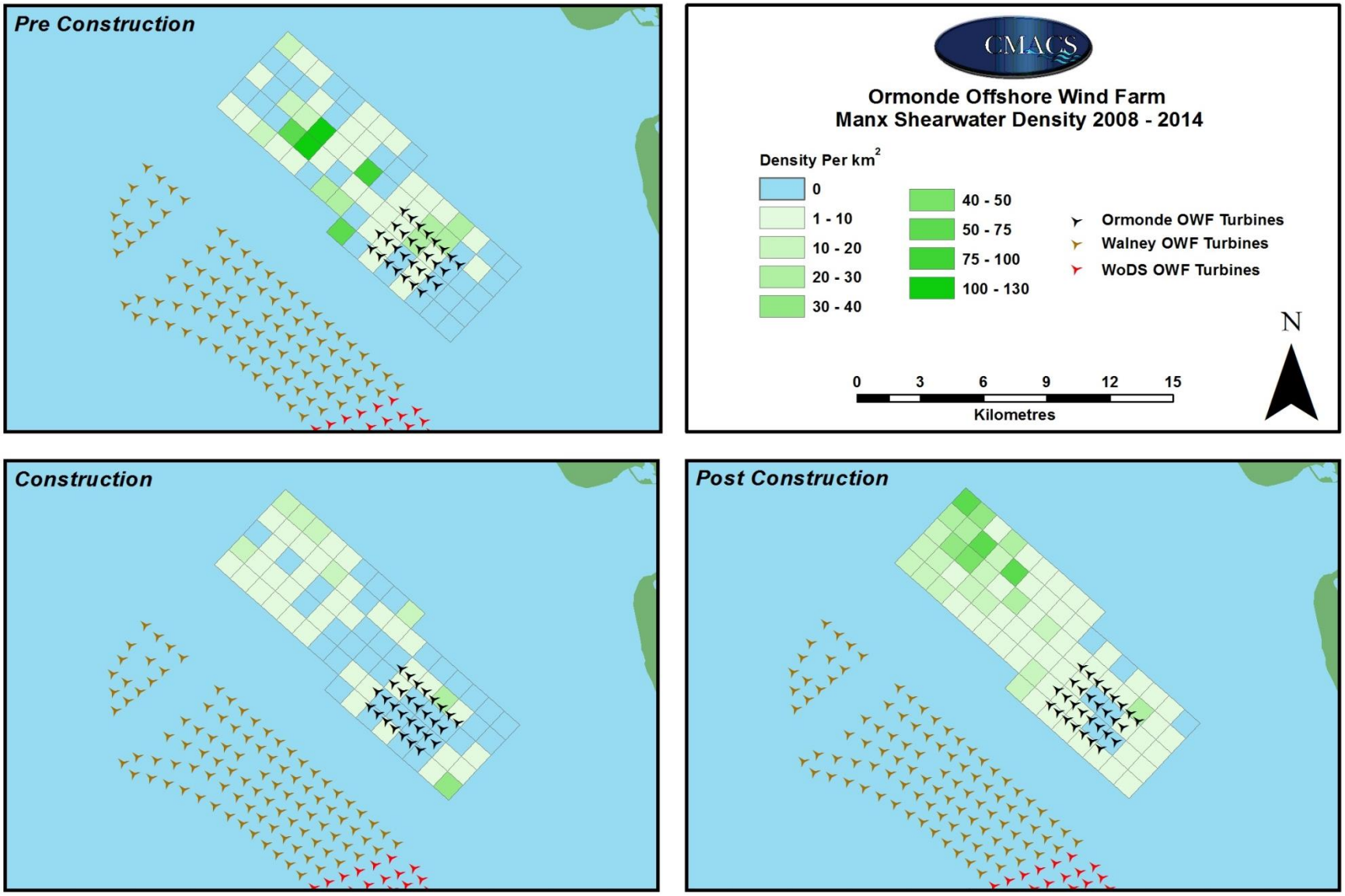


Figure 20. The densities of Manx shearwater across the survey area recorded each phase (birds/km^2). Densities in each grid square are corrected for distance and are averages across surveys within each year.

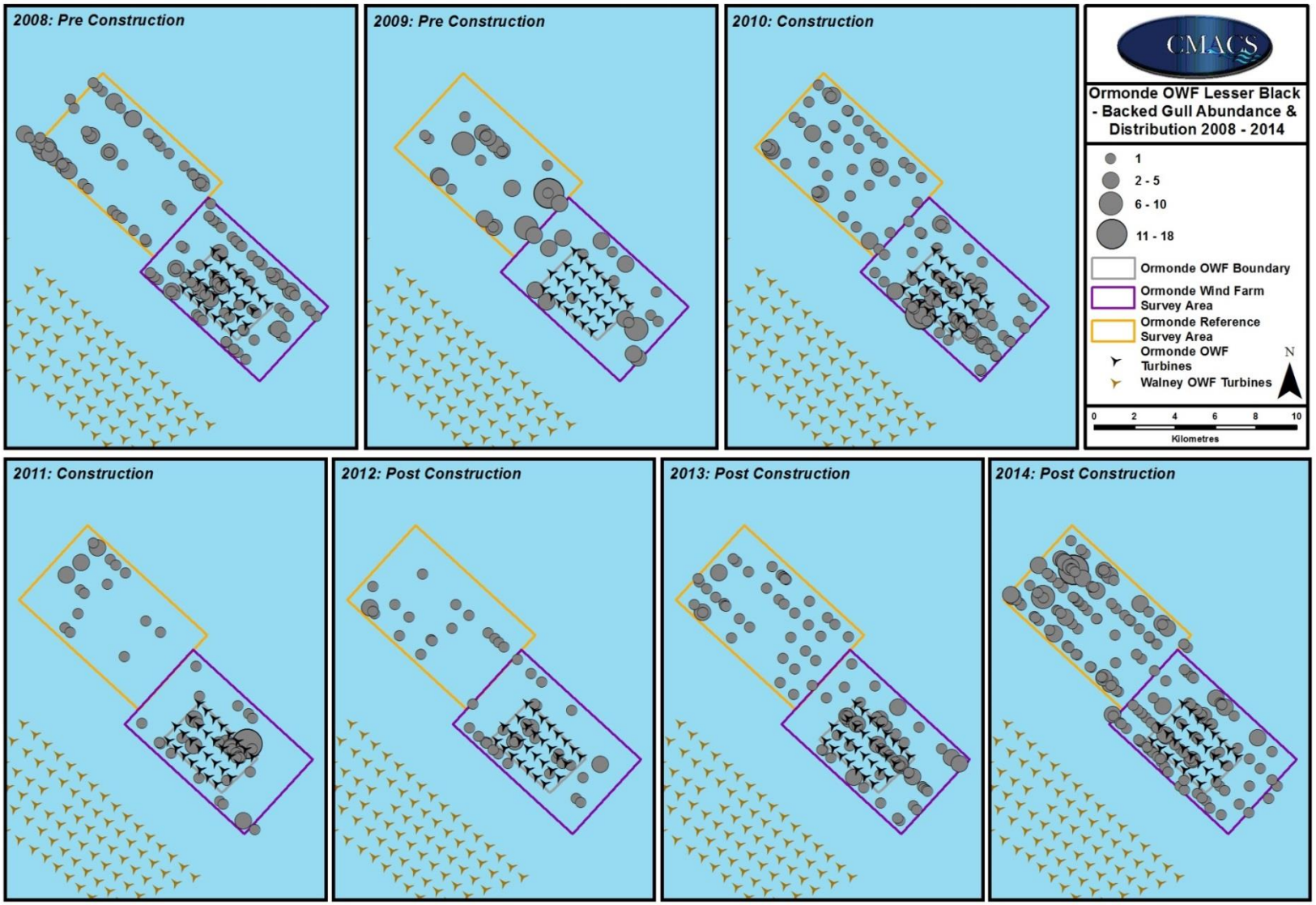


Figure 21. Distribution and abundance of lesser black-backed gull on Ormonde survey transects 2008 to 2014.

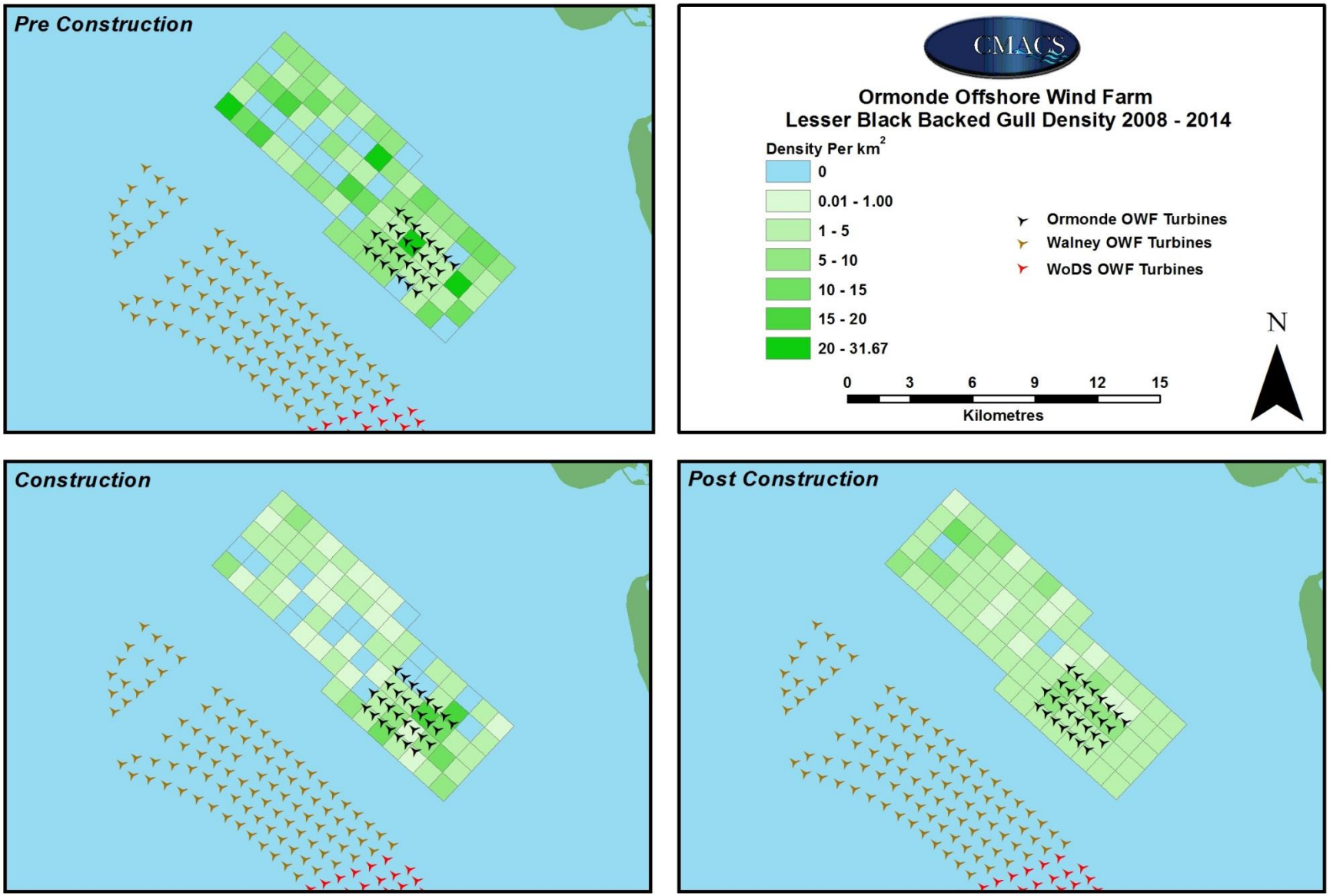


Figure 22. The densities of lesser black-backed gull across the survey area recorded each phase (birds/km^2). Densities in each grid square are corrected for distance and are averages across surveys within each year.

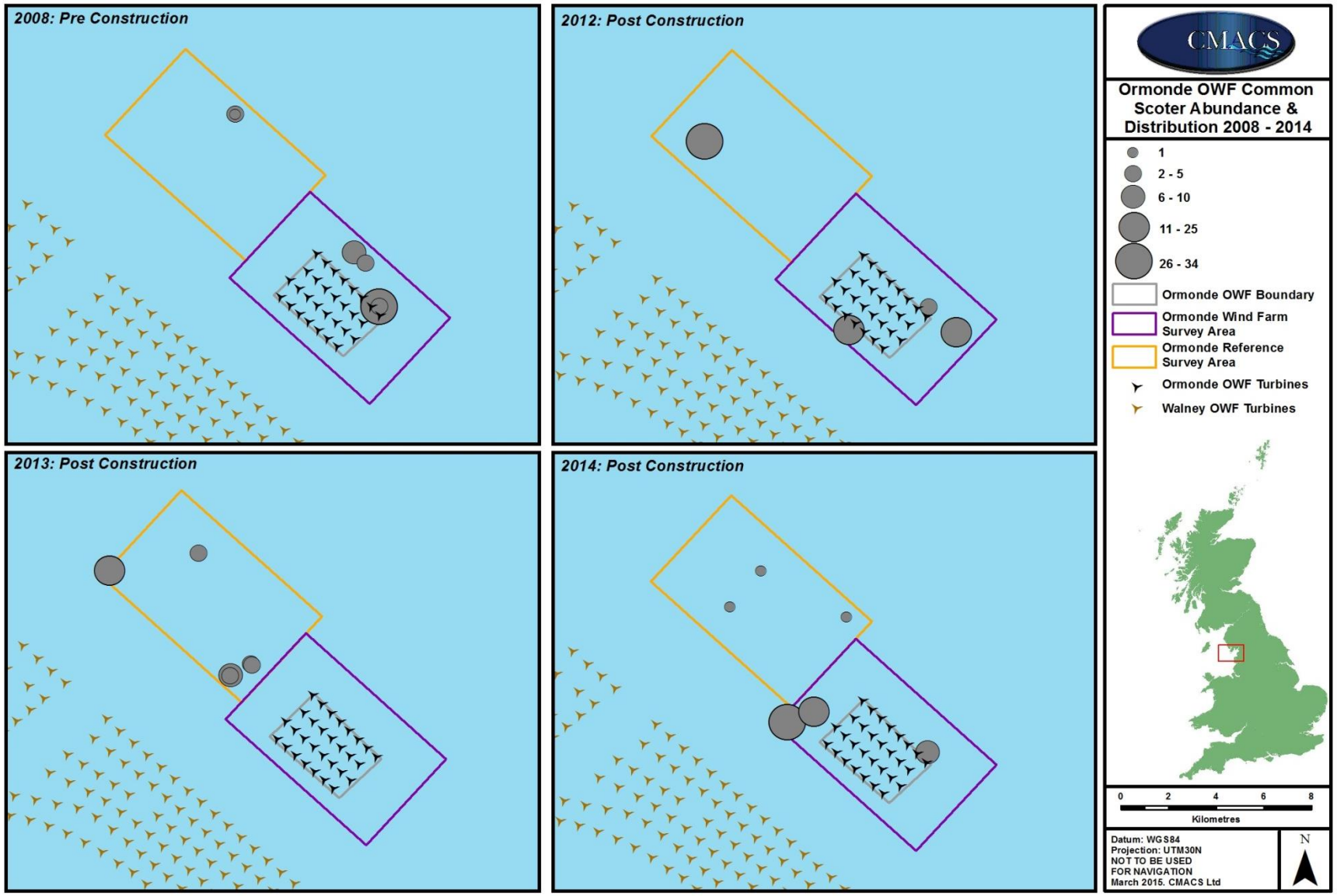


Figure 23. Distribution and abundance of common scoter on Ormonde survey transects 2008 to 2014. Scoter were rare in the survey area and were not recorded in 2009, 2010 or 2011.

STATISTICAL ANALYSIS

Question 1: *Are there any differences between the number of birds recorded from the reference area and the wind farm area in each survey year?*

The mean number of birds recorded from the reference and wind farm survey areas are compared between years in Figure 24 (note only those in transect are included; i.e. those in bands A to D). In a previous report (CMACS, 2013a), it was suggested that there may have been a recovery of bird abundance in the wind farm in the post-construction phase (2012-2013) after a sharp decrease during the second year of construction (in 2011). Data from the 2014 surveys do not support this suggested trend with much lower abundance of birds in the wind farm in 2014 compared to 2012 and 2013. The reference area shows the same trend of increase then decrease in the post-construction phase but without the relatively large initial decrease in 2011. The decrease in abundance of birds in 2011 in the wind farm survey area but not in the reference survey area does indicate a potential influence of the wind farm on bird numbers. However, the post-construction trend appears to be owing to factors beyond the wind farm as they are mirrored in the reference area.

Statistical analysis did not find any significant difference in bird numbers between years in either the reference or wind farm survey areas, possibly owing to the high variability in bird numbers both within and between years (see below, and Appendix 3).

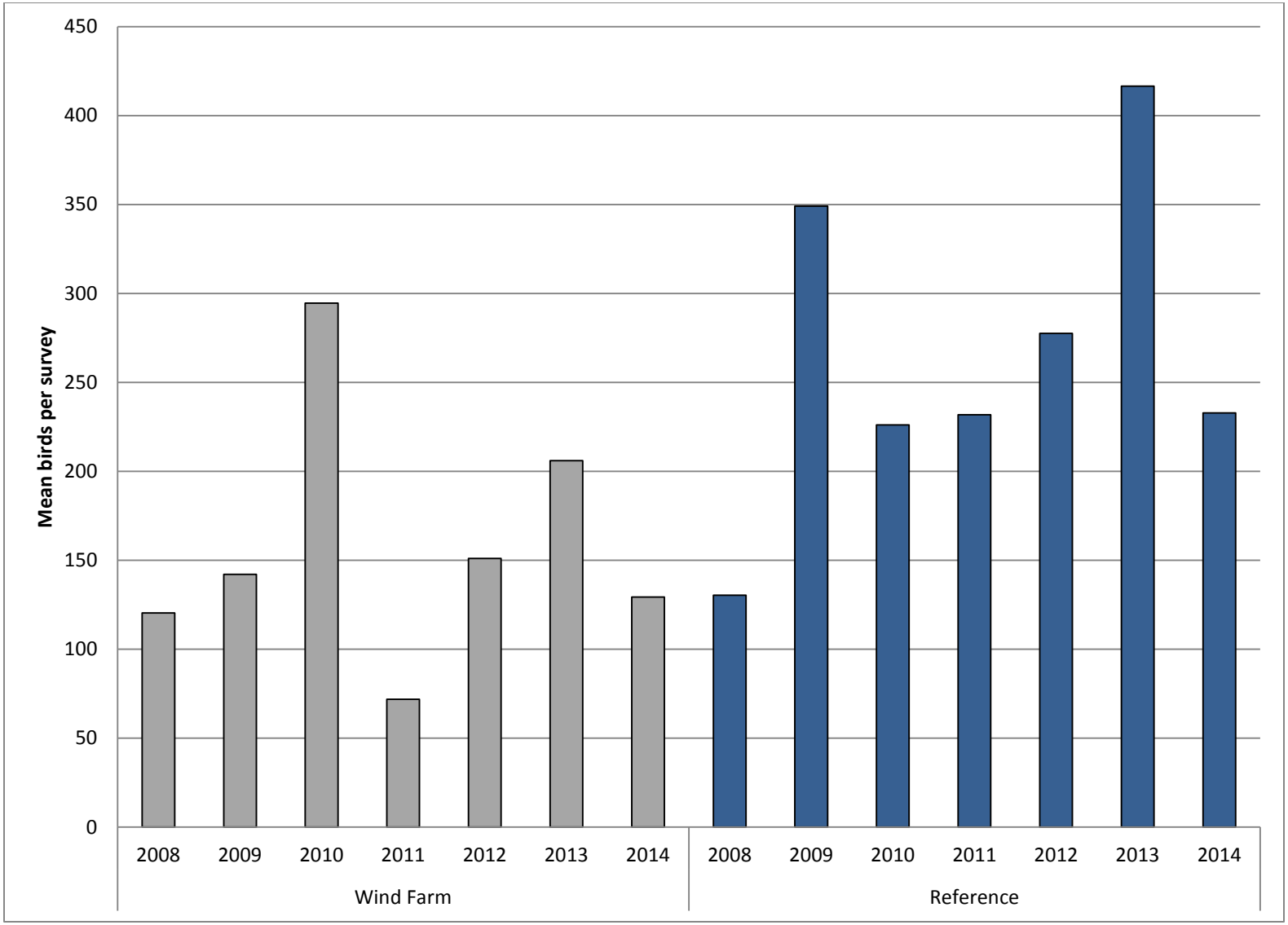


Figure 24. Mean number of birds recorded within the survey transect (in flight and on the sea records combined) from the wind farm (grey) and reference (blue) areas each year.

Question 2: *Is there a difference between the construction phases in the total number of birds recorded?*

Bird numbers were highly variable both between survey months and years (Figure 24 and Table 2). The majority of this variability was owing to changes in the numbers of just a few species; for example guillemot numbers amounted to just 4% in one survey but were 78% of the total number of birds in another survey. Manx shearwaters were similarly variable; from 0 to 73% of bird numbers in separate surveys.

The plot in Figure 24 indicates that abundance of birds within the wind farm decreased in 2011, the latter part of the construction phase and year of turbine installation. Since similar decreases were not recorded within the reference area, this suggests that construction operations, including wind turbine installation, may have deterred birds from entering the array area to a certain extent. Numbers appeared to recover after construction until 2013, a trend of increasing bird abundance that was matched in the reference area, followed by a general decrease in abundance in 2014. Statistical analysis carried out to investigate apparent trends indicates that there has been a significant decrease in the total number of birds in the wind farm area from the pre-construction (2009) and construction phases (2010-2011) to the post-construction phase (2012-2014) ($Z=-2.22$, $\rho < 0.05$). The data was analysed further with separate tests for individual species to investigate whether this was an overall decline or only in a few species, which is described in the next section.

Table 2. Total number of birds recorded in transect (bands A to D) from the wind farm (upper table) and reference (lower table) areas per survey month in each year. Numbers are not corrected for distance or weather.

Wind Farm	May	July	August	September
2009	320	—	—	—
2010	558	92	282	265
2011	90	32	46	119
2012	93	258	40	213
2013	45	313	174	292
2014	104	188	104	121

Reference Area	May	July	August	September
2009	609	—	—	—
2010	328	130	209	237
2011	210	160	22	535
2012	85	529	44	452
2013	55	815	110	686
2014	53	643	104	131

Question 3: *Are there any particular species of bird that have decreased or increased in any of the construction phases?*

With the addition of 2014 data, there are some apparent trends in the abundance of the most commonly recorded species throughout the survey programme, including the two key species (Figure 25 to Figure 29).

Estimates of the ratios of Manx shearwaters between wind farm and reference areas suggested a decrease with time but owing to the great variability of counts (see Figure 25), both between individual sightings and between surveys, a significant change could not be detected.

There was considerable variability in lesser black-backed gull numbers between years in both the wind farm and reference areas, but average numbers by phase showed a steady decrease in abundance from baseline to post-construction in the wind farm (Figure 26); a trend that was not repeated in the reference area. The results of the statistical analysis, however, suggest that there was an increase in the number of lesser black-backed gull in the wind farm area from the pre-construction (2009) to construction phase (2010-2011) ($\rho \leq 0.05$). In contrast, statistical analysis revealed a significant decrease of lesser black-backed gull ($\rho \leq 0.01$) in the wind farm area from the construction phase (2010-2011) to the post-construction phase (2012-2014).

The abundance of guillemot in the wind farm does not show any particular trend but there was a steady increase in average by phase in the reference area, although with considerable inter-annual variability (Figure 27). Statistical analysis suggests that there has been a significant decrease ($\rho \leq 0.001$) in the number of guillemot using the wind farm area since the array became operational and that abundance may have decreased by 50% in the post-construction phase (i.e. from 2012 to 2014). The statistical analysis found no discernible change in guillemot abundance from the pre-construction to the end of the construction phase i.e. from 2009 to 2011.

Gannet abundance was highest during the pre-construction phase in both the wind farm and reference areas, but there was a continual decrease through the construction and post-construction phases in the wind farm area (Figure 28). Statistical analysis indicated that this was a significant trend ($\rho \leq 0.001$) post-construction and that there has been a decrease in the number of gannet in the wind farm compared to the reference area.

The increase in kittiwakes in the wind farm area reported in 2013 has been followed by a decrease in numbers in 2014 (Figure 29), and kittiwake numbers in the reference area have been decreasing steadily since the latter half of the construction phase (2011). In terms of average numbers by phase, kittiwake abundance has increased significantly in the wind farm area ($\rho \leq 0.05$) since construction was completed, but with no change in the wind farm area during the other phases.

All outputs of statistical analysis are provided in Appendix 4.

Owing to the discrepancy between the number of baseline, construction and post-construction surveys, as well as the variability of bird abundances between surveys as described above, it was decided to run the comparative tests a second time but using only the May survey from

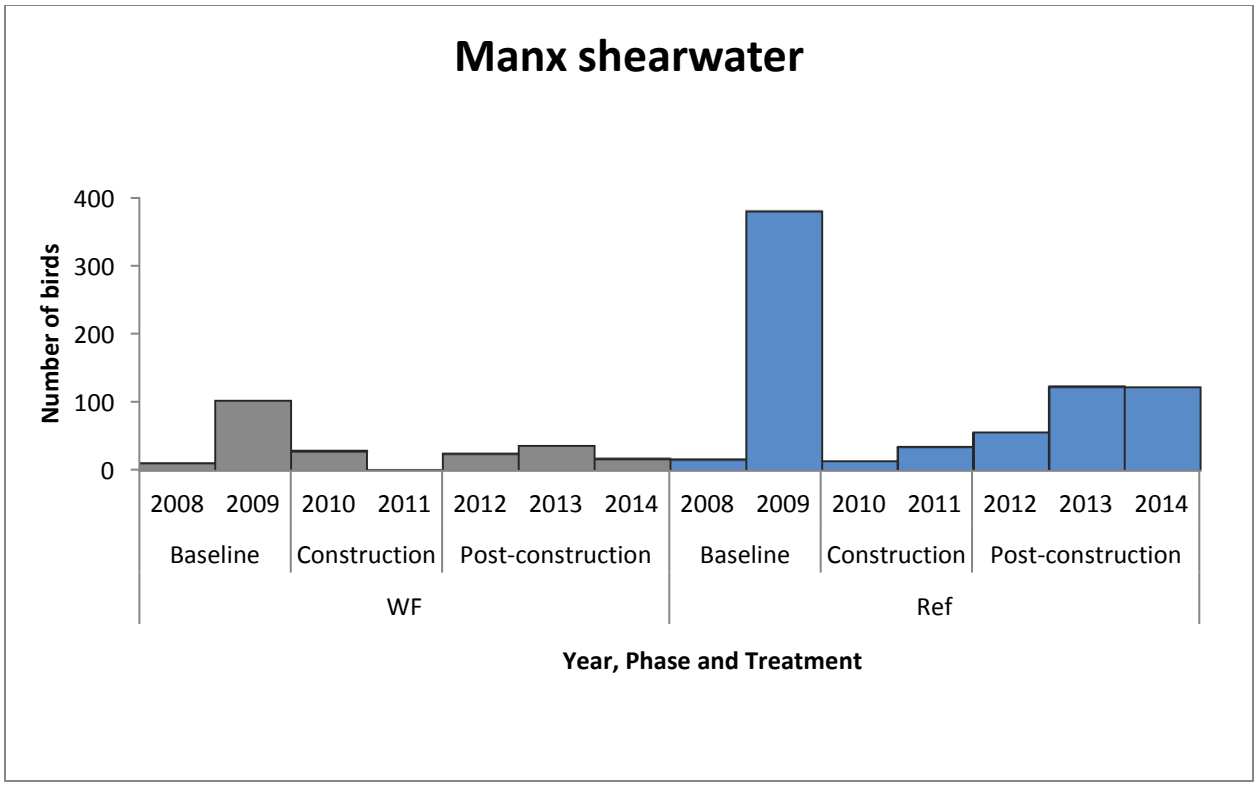
each year. The results of the May-only comparison (see Appendix 5) suggest that there was a statistically significant ($\rho<0.05$) increase in Manx shearwater numbers in the wind farm area during the construction phase (2010 to 2011) but that there was a statistically significant decrease ($\rho<0.05$) in guillemot numbers during the post-construction phase (2012 to 2014). There was no evidence of changes in the abundance of gannet, lesser-black backed gull and kittiwake in relation to the May surveys only.

Question 4: *Are there any differences in the proportion of birds in flight and those on the surface of the water between phases?*

Changes in the abundance of gannet, guillemot, lesser black-backed gull, Manx shearwater and kittiwake in the wind farm area between monitoring phases were further investigated with tests to establish if there had been a change in the proportion of birds in flight compared to those on the water. Owing to the limited amount of records of birds in flight, comparisons were made using data from the 12 post-construction surveys only.

No significant difference in the ratio of birds in flight to birds on the water was found for guillemot, kittiwake, lesser black-backed gull or Manx shearwater between the reference area and the wind farm area.

There was, however, a significant difference ($t_{11}=2.85$, $\rho <0.01$) in the ratio of flying gannets to those on the surface between the wind farm area and reference area, with a lower proportion of birds on the water in the wind farm. This indicates that gannet are less likely to be resting in the wind farm area and more likely to be transiting through it. It is unlikely that the greater proportion of birds in flight in the wind farm area represents a greater tendency towards foraging in this area as previous analyses (see Question 3, above) have found that abundance of gannet was significantly lower in the wind farm area compared to the reference area from the construction to the post-construction phases.



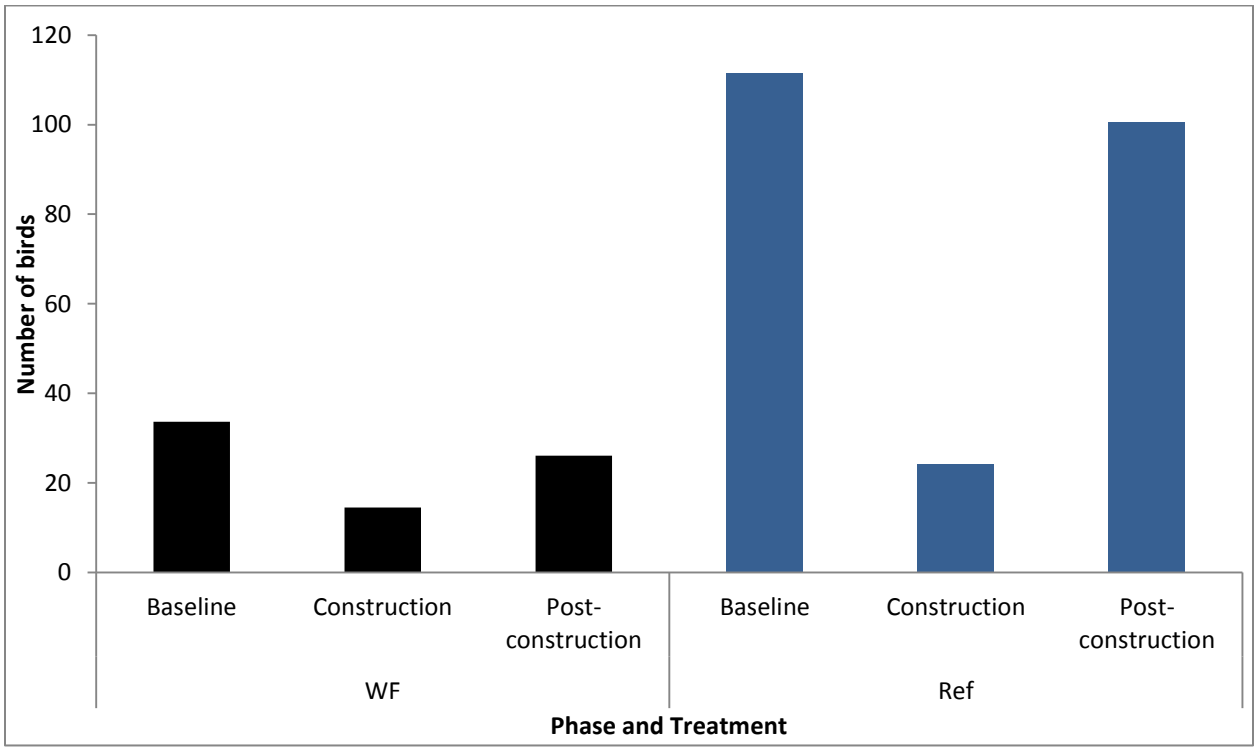
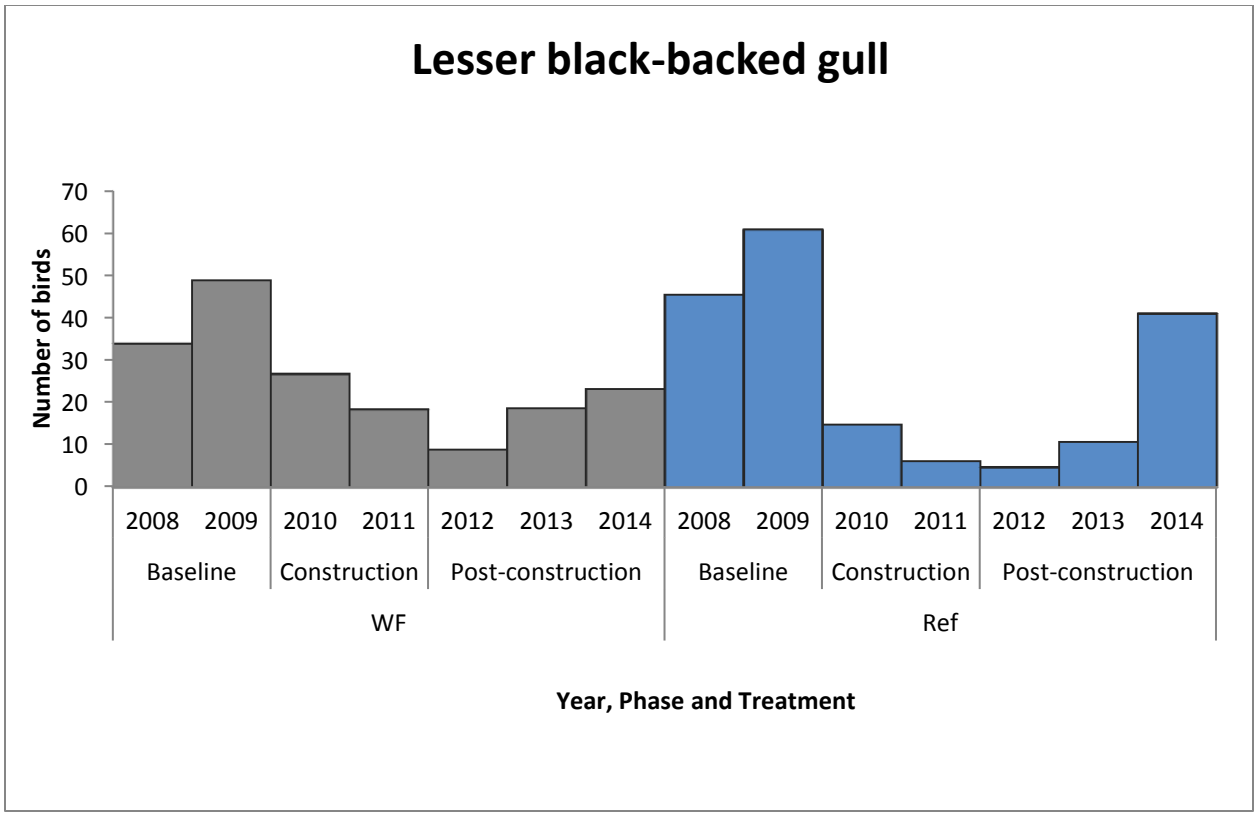


Figure 25. Average counts of Manx shearwater by year (upper plot; grey for wind farm, blue for reference) and phase (lower plot; black for wind farm, blue for reference). Based on distance-corrected data



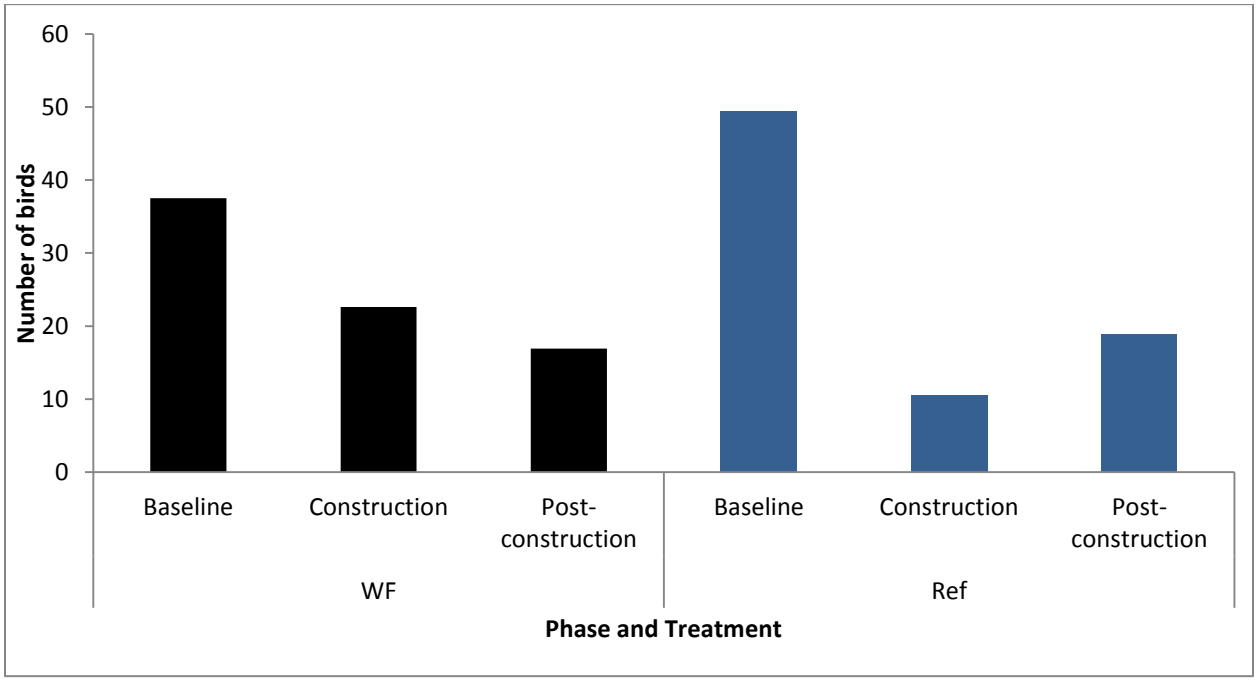


Figure 26. Average counts of lesser black-backed gull by year (upper plot; grey for wind farm, blue for reference) and phase (lower plot; black for wind farm, blue for reference). Based on distance-corrected data.

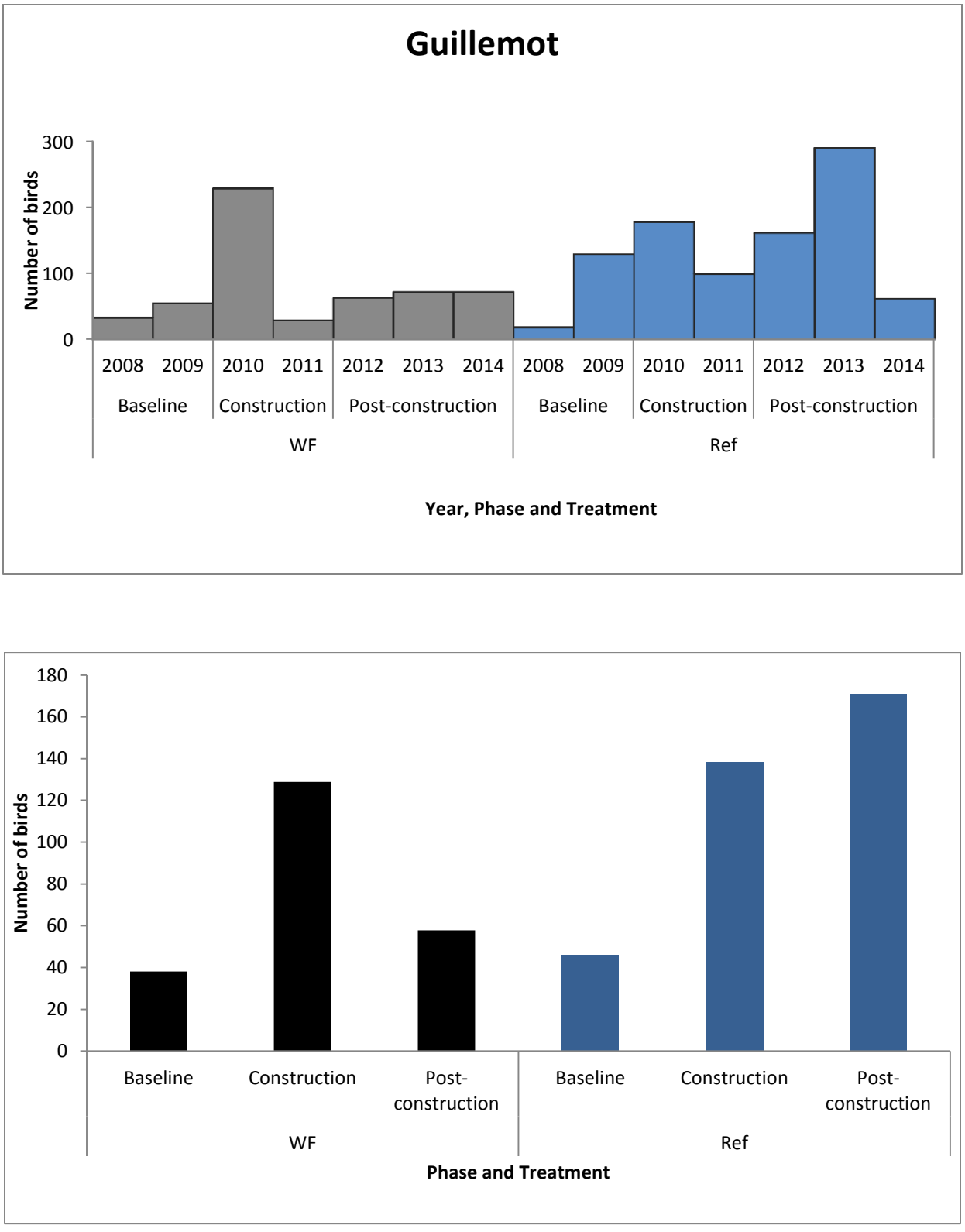


Figure 27. Average counts of guillemot by year (upper plot; grey for wind farm, blue for reference) and phase (lower plot; black for wind farm, blue for reference). Based on distance-corrected data.

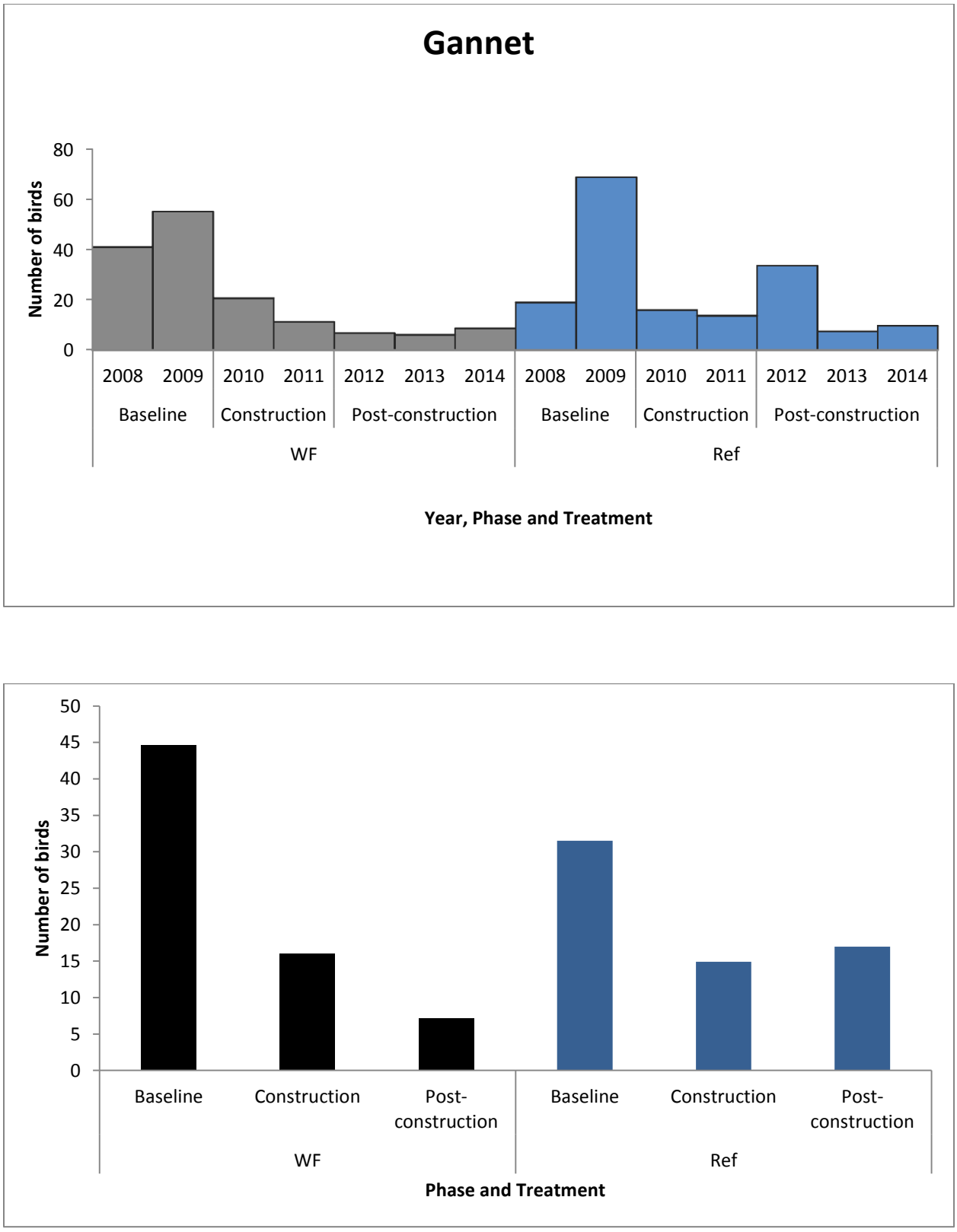
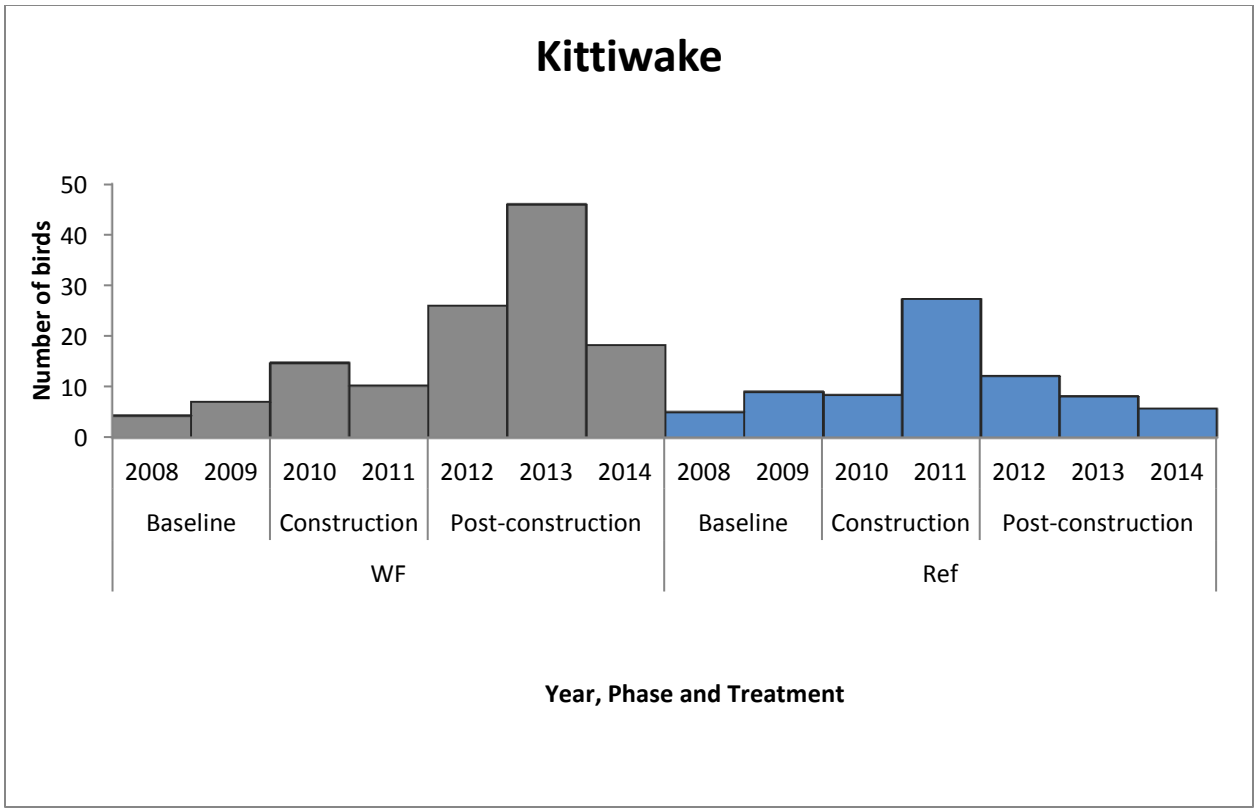


Figure 28. Average counts of gannet by year (upper plot; grey for wind farm, blue for reference) and phase (lower plot; black for wind farm, blue for reference). Based on distance-corrected data.



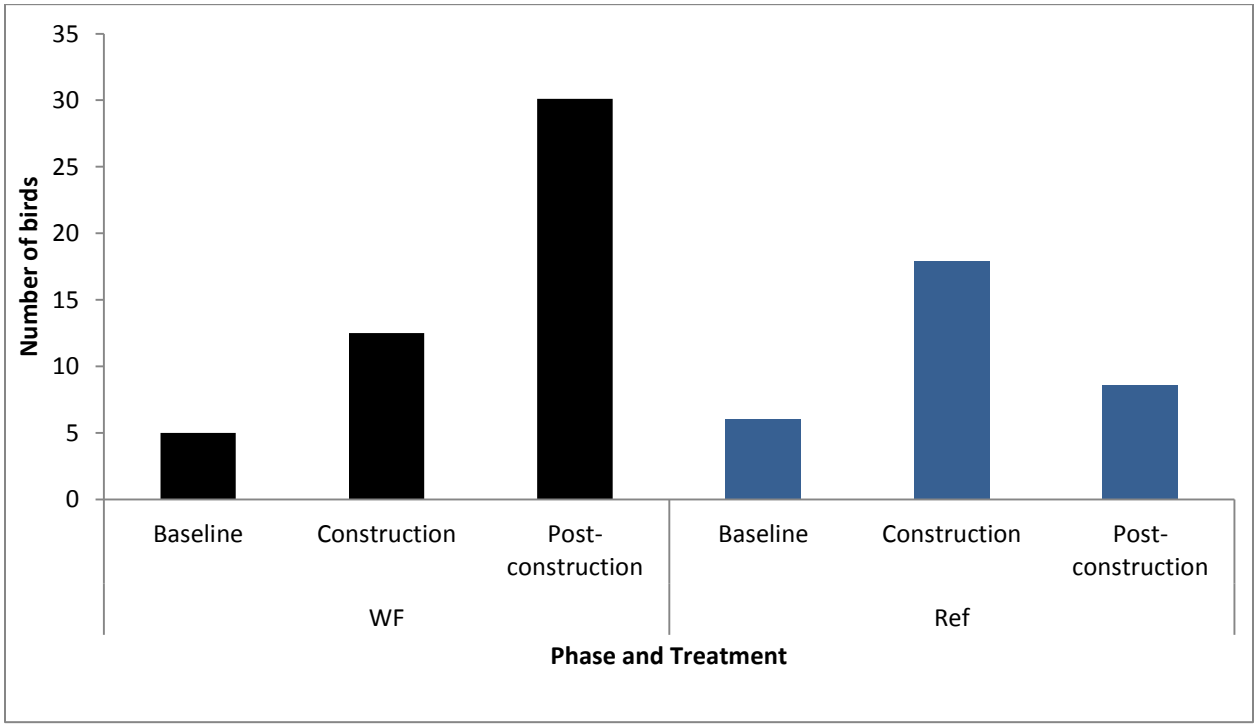


Figure 29. Average counts of kittiwake by year (upper plot; grey for wind farm, blue for reference) and phase (lower plot; black for wind farm, blue for reference). Based on distance-corrected data.

4. DISCUSSION

The surveys around the Ormonde OWF area from 2008 to 2014 have described an avifauna that can be considered typical of the eastern Irish Sea in spring and summer. Large numbers of shearwaters and auks are linked to relatively local breeding colonies; as are the various species of gulls encountered, as well as gannet. In addition, the surveys have shown that some migrant birds, including terrestrial species, also pass through the area.

The bird surveys at the Ormonde OWF and reference area have elucidated some changes in the distribution of seabirds from pre-construction to the first few years of operation. The purpose of the boat-based surveys, in line with objective 1 of the Ormonde EMP, was to determine whether there was a change in the distribution, use, abundance, behaviour and passage of birds in relation to wind farm construction and operation, with a focus on two key species:

- Manx shearwater *Puffinus puffinus*
- Lesser black-backed gull *Larus fuscus*

Manx shearwater and lesser black-backed gull were recorded in sufficient numbers to be analysed. Several other species (gannet, guillemot and kittiwake) were also abundant enough to examine for trends as per the recommendations of the MMO (review published in 2014).

The Ormonde Environmental Statement (Eclipse Energy Company Limited, 2005) predicted a low magnitude of effect on gannet and guillemot with regard to disturbance in the construction and operational phases, meaning that one to five percent of the population would be affected. Negligible magnitude of effect was predicted for kittiwake and lesser black-backed gull, meaning that less than one percent of the population were expected to be affected. A low magnitude impact of construction was predicted for Manx shearwater but a negligible effect of operation was predicted for this species.

The high variability in abundance of Manx shearwater in both space and time prevented any trends being elucidated from the full dataset by statistical analysis, though the tests on the May data only indicated a trend of increasing numbers in the wind farm area when comparing pre-construction to construction. Observations from mapping, however, suggested that these birds were avoiding the turbine array and that some disturbance may have occurred as a result of the construction and operation of the wind farm.

The abundance of lesser black-backed gull, however, had moved from a bias towards the wind farm to a bias towards the reference area from the construction phase to the operation phase. This is in contrast to the trend of an increasing proportion of lesser black-backed gull in the wind farm area identified in 2013 and the observed ‘preference’ for turbine arrays noted elsewhere. Investigating this trend further shows that there has not actually been a decrease in the absolute number of lesser black-backed gulls in the wind farm area (they were, in 2014, at their highest abundance since 2010), but numbers had increased by a far greater amount in the reference area. During this relatively large influx in 2014, the reference area bias suggests that lesser

black-backed gulls were not showing a 'preference' for the wind farm area, based on the assumption that they would have had a more even distribution over the survey area had the turbine array not been present. It was also the first time since the pre-construction surveys (2008 and 2009) that the numbers of lesser black-backed gull were higher in the reference area than in the wind farm area. When the data is examined in the context of phases, however, the numbers of lesser black-backed gulls in the reference area were higher than the wind farm area during the pre-construction and operation phases and vice versa in the construction phase. Statistical analysis of bird data reported in 2013 (on data from 2009 to 2013), suggested that lesser black-backed gull showed a preference for the wind farm area when comparing pre-construction phase data and construction phase data but that no such preference was evident when comparing the construction phase to the post-construction phase. In 2014, statistical analysis indicates a lower abundance in the wind farm area compared to the reference area from construction to post-construction, perhaps suggesting a return to baseline abundance levels in the wind farm area.

With regard to more general changes in bird abundance in the survey area, much of the overall trend in the wind farm was the result of a significant decrease of guillemot, one of the more common species in the surveys, also with evidence for a decrease in gannet abundance.

The decrease of both gannet and guillemot in the wind farm area relative to the reference area has been consistent when comparing the construction phase (2010-2011) to the post-construction phase (2012-2014), suggesting that the presence of the wind farm may be a factor in the lowering abundance with time. Surveys at other offshore wind farms, such as Horns Rev and Nysted in Denmark, also recorded a decline in gannet and auks post-construction (Fox & Petersen, 2006). When the downward trend in gannet and guillemot abundance was first identified, the possibility of habituation was mooted (CMACS, 2013b). Addition of the most recent results (2014) into the statistical analysis suggests that habituation has not occurred (which would be associated with a stabilisation or increase in numbers).

The precise reason for the decline in abundance of gannet and guillemot is not known but the following reasons have been postulated (Drewitt & Langston, 2006):

- A barrier effect created by the presence of the turbines;
- Disturbance owing to the vessel traffic associated with wind farm operation;
- Change or loss of habitat.

Studies at other wind farms have revealed that gulls can show a 'preference' for turbine arrays (Petersen *et al.*, 2004) and at Ormonde, this appears to be the case with regard to kittiwake. This small gull was regularly observed perching on or flying around the transition pieces of the turbines and the substation. The trend of distribution of kittiwake indicates an attraction effect of the turbine structures. Herring gull, which were not subject to statistical analysis owing to generally low numbers, also appear to have been drawn into the wind farm area with time; they were virtually absent from the site up until the operation phase, when in 2012, abundance increased to over 40 individuals and has remained elevated ever since. Numbers also

increased in the reference area but to a lesser degree and with less consistency. Herring gulls have been regularly observed foraging on and around the transition pieces.

Based upon population estimates for the Irish Sea (Mitchell *et al.,* 2004), a crude calculation of the proportion of the population of each species in the Ormonde wind farm area was made using average monthly counts from the construction and post-construction phases. In all cases, the counts from the wind farm area and reference area were less than one percent of the regional population. Furthermore, these were likely over-estimates because population estimates were based on counts from breeding colonies and every population contains a large proportion of immature individuals and non-breeding adults. The results of the monitoring surveys in the Ormonde wind farm area, therefore, support the predictions of the Environmental Statement and the effect is negligible in the context of Irish Sea populations of these species.

Limitations

While the survey programme was completed without any omissions (i.e. all surveys planned were successfully carried out), there were some aspects [of the survey programme] that imposed limitations on the statistical analysis and its interpretation:

- Four months were surveyed per year in accordance with the survey programme, and one survey was carried out in each of those months. Birds, being highly mobile organisms, can vary in abundance in a particular location greatly over short periods of time.
- The wind farm is not an isolated development in the eastern Irish Sea as there are several other developments in the general area (Walney I is 4 km from Ormonde, Walney II is 4.4 km distant, West of Duddon Sands is 4.5 km away and Barrow is 10 km distant with all measurements between nearest boundaries). These other wind farms are beyond the 600 m zone of displacement effect and were not predicted to have a cumulative effect with Ormonde OWF (Eclipse Energy Company Limited, 2005).
- Limitations with the reference area in relation to comparability with the wind farm area in terms of habitat available and use by seabirds. Many offshore wind farms have had such issues with selecting and surveying appropriate reference areas (MMO, 2014).

Conclusion

To conclude, surveys have taken place within the Ormonde OWF survey area and reference survey area in each year from 2008 to 2014, encompassing the pre-construction, construction and operational phases of the project. Analysis of the data from the monitoring programme has revealed a statistically significant decrease in abundance of gannet and guillemot within and around the turbine array since the commencement of the operational phase (2012). Manx shearwater may have avoided the turbine array specifically but there is only circumstantial evidence for this. Lesser black-backed gull also appear to have decreased post-construction but there is not such a consistent trend, as abundance increased in the wind farm area during the construction phase. In contrast, kittiwake appear to have been attracted to the site and have become more common in the wind farm area than before the turbines were erected. The wind farm appears to have had a disturbance effect on at least two species encountered in the surveys but this effect is well within the magnitude predicted in the Environmental Statement. These findings are summarised in Table 3 below.

Table 3. Summary of results and analyses of the five most abundant species in the surveys.

Species	Abundance and density maps (Figure 19 to Figure 22)	Average counts by phase (Figure 25 to Figure 29)	Statistical analysis (section 3.4)	ES prediction	Conclusion
Manx shearwater	These maps suggest that there was generally a 'preference' (2010 excepted) for the reference area, even before construction.	Numbers varied greatly between phases but were higher in the reference area than in the wind farm area in all phases.	Estimates of the ratios of Manx shearwaters between wind farm and reference areas suggested a decrease in the wind farm with time, but owing to the great variability of counts a significant change could not be detected.	A low magnitude impact of construction was predicted for Manx shearwater. A negligible effect of operation was predicted.	Manx shearwater may have avoided the turbine array specifically but there is only circumstantial evidence for this. Results are in agreement with ES predictions
Lesser black-backed gull	The abundance maps suggest a relatively even distribution of birds in the reference and wind farm areas throughout the surveys but with higher overall density in the pre-construction phase. Density was also higher in the wind farm area in the construction phase.	The wind farm area showed a steady decline in average numbers from the pre-construction to post-construction. The reference area was much more variable but with lowest numbers in the construction phase.	Results suggested an increase in abundance in the wind farm relative to the reference area from the baseline to the construction phase. In the post-construction phase however, there were fewer birds in the wind farm area than the reference area.	A negligible magnitude impact of construction and operation was predicted.	Lesser black-backed gull abundance has fluctuated markedly over the years of survey but potentially point to a decline in abundance in the wind farm area. Effects are in agreement with ES predictions.
Guillemot	N/a, only created for the species of interest	A large increase in abundance in the reference area from pre- to post-construction which was not mirrored in the wind farm area.	No change in numbers from pre-construction to construction phase. Highly significant decrease in numbers in the wind farm when comparing data from the construction phase to the post-construction phase.	A low magnitude impact of construction and operation was predicted.	Survey results suggest that guillemot have declined in the wind farm area since construction of the wind farm. The guillemot population of the Irish Sea is large and therefore the results are in line with ES predictions.

Species	Abundance and density maps (Figure 19 to Figure 22)	Average counts by phase (Figure 25 to Figure 29)	Statistical analysis (section 3.4)	ES prediction	Conclusion
Gannet	N/a, only created for the species of interest	A general decrease in numbers from pre- to post-construction phase, which was much more pronounced in the wind farm area.	No change in numbers from pre-construction to construction phase. Highly significant decrease in numbers in the wind farm when comparing data from the construction phase to the post-construction phase.	A low magnitude impact of construction and operation was predicted.	Survey results suggest that gannet have declined in the wind farm area since construction of the wind farm. The numbers recorded in the surveys were low and therefore the results are in line with ES predictions.
Kittiwake	N/a, only created for the species of interest	Varying numbers with time in the reference area but a steady increase in abundance in the wind farm area from the pre- to post-construction phases.	No change in numbers from pre-construction to construction phase. Significant increase in numbers in the wind farm when comparing data from the construction phase to the post-construction phase.	A negligible magnitude impact of construction and operation was predicted.	Kittiwake have been attracted to the wind farm area by the construction of the turbine array. Results are in line with the ES predictions.

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APPENDICES

Appendix 1. Total numbers of birds recorded in each month's survey in 2014

Wind farm area

		Month				
Common name	**Species name**	**May**	**July**	**August**	**September**	**Total**
Auk sp.	Alcidae	0	1	0	0	**1**
Black-headed gull	*Chroicocephalus ridibundus*	1	1	0	0	**2**
Common gull	*Larus canus*	0	1	0	2	**3**
Common scoter	*Melanitta nigra*	52	0	0	0	**52**
Common tern	*Sterna hirundo*	0	0	3	0	**3**
Gannet	*Morus bassanus*	4	19	8	8	**39**
Great black-backed gull	*Larus marinus*	0	2	0	1	**3**
Guillemot	*Uria aalge*	31	13	7	76	**127**
Gull sp.	Laridae	0	4	4	0	**8**
Herring gull	*Larus argentatus*	18	24	11	8	**61**
Kittiwake	*Rissa tridactyla*	3	105	17	4	**129**
Lesser black-backed gull	*Larus fuscus*	1	25	60	14	**100**
Manx shearwarer	*Puffinus puffinus*	0	69	1	0	**70**
Meadow pipit	*Anthus pratensis*	0	0	0	1	**1**
Razorbill	*Alca torda*	0	1	0	3	**4**
Sandwich tern	*Sterna sandivicensis*	0	0	0	4	**4**
Swallow	*Hirundo rustica*	2	0	0	0	**2**
Total		**112**	**265**	**111**	**121**	**609**

Reference area

		Month				
Common name	**Species name**	**May**	**July**	**August**	**September**	**Total**
Auk sp.	Alcidae	0	0	0	5	**5**
Common scoter	*Melanitta nigra*	0	1	0	2	**3**
Common tern	*Sterna hirundo*	0	0	5	0	**5**
Dunlin	*Calidris alpina*	0	0	0	1	**1**
Gannet	*Morus bassanus*	10	30	2	8	**50**
Great black-backed gull	*Larus marinus*	0	3	0	0	**3**
Guillemot	*Uria aalge*	19	92	18	85	**214**
Gull sp.	Laridae	0	0	8	0	**8**
Herring gull	*Larus argentatus*	0	2	9	2	**13**
Kittiwake	*Rissa tridactyla*	0	9	6	7	**22**
Large gull sp.	Laridae	0	0	0	4	**4**
Lesser black-backed gull	*Larus fuscus*	23	62	55	12	**152**
Manx shearwater	*Puffinus puffinus*	0	525	2	1	**528**
Puffin	*Fratercula arctica*	1	0	0	0	**1**
Razorbill	*Alca torda*	4	0	0	8	**12**
Sandwich tern	*Sterna sandivicensis*	0	0	0	5	**5**
Swallow	*Hirundo rustica*	1	0	0	0	**1**
Swift	*Apus apus*	0	0	1	0	**1**
Total		**58**	**724**	**106**	**140**	**1028**

Appendix 2. Numbers of marine mammals recorded during each month's surveys in 2014

		Month				
Common	**Latin**	**May**	**July**	**August**	**September**	**Total**
Grey seal	*Halichoerus grypus*	1	1	2	1	**5**
Harbour Porpoise	*Phocoena phocoena*	0	1	1	5*	**7**
Total		**1**	**2**	**3**	**6**	**12**

*NB – 3 were recorded in between transects

Appendix 3. Statistical Outputs: Comparison of number of individuals between construction phases

All birds

Overall Totals	Ormonde	Reference
Pre-Construction (1 survey)	320	609
Construction (8 surveys)	1484	1831
Post-Construction (12 surveys)	2021	3792

Changes at wind farm	Estimate	Lower Limit	Upper Limit
Pre-construction to Construction	1.54	0.80	2.98
Pre-construction to Operation	1.01	0.54	1.91
Construction to Operation	0.66	0.45	0.96

For the third contrast (construction to operation), the value of the test statistic is z=-2.22. This is significant at the 5% level i.e. $\rho<0.05$.

Appendix 4. Statistical outputs: Comparison of number of individuals between construction phases, by species.

Guillemot

Overall Totals	Ormonde	Reference
Pre-Construction (1 survey)	54	121
Construction (8 surveys)	780	879
Post-Construction (12 surveys)	507	1584

Changes at wind farm	Estimate	Lower Limit	Upper Limit
Pre-construction to Construction	1.99	0.69	5.74
Pre-construction to Operation	0.75	0.26	2.16
Construction to Operation	0.37	0.24	0.58

For the third contrast (construction to operation), the value of the test statistic is z=-4.50. This is significant at the 0.1% level i.e. ρ<0.001. The remaining contrasts show no significant difference.

Lesser black-backed gull

Overall Totals	Ormonde	Reference
Pre-Construction (1 survey)	48	61
Construction (8 surveys)	185	80
Post-Construction (12 surveys)	196	212

Changes at wind farm	Estimate	Lower Limit	Upper Limit
Pre-construction to Construction	2.94	1.25	6.92
Pre-construction to Operation	1.17	0.53	2.59
Construction to Operation	0.40	0.22	0.73

For the first contrast (pre-construction to construction), the value of the test statistic is z=2.52 and is significant at the 5% level i.e. ρ<0.05. For the third contrast (construction to operation), the value of the test statistic is z=-3.03 and is significant at the 1% level i.e. ρ<0.01. There was no significant difference from pre-construction to operation.

Kittiwake

Overall Totals	Ormonde	Reference
Pre-Construction (1 survey)	7	10
Construction (8 surveys)	100	118
Post-Construction (12 surveys)	361	88

Changes at wind farm	Estimate	Lower Limit	Upper Limit
Pre-construction to Construction	1.21	0.10	14.20
Pre-construction to Operation	5.86	0.51	67.32
Construction to Operation	4.84	2.03	11.55

For the third contrast (construction to operation), the value of the test statistic is z=3.63 and is significant at the 0.1% level i.e. ρ<0.001. The remaining contrasts show no significant difference.

Gannet

Overall Totals	Ormonde	Reference
Pre-Construction (1 survey)	51	69
Construction (8 surveys)	119	119
Post-Construction (12 surveys)	81	208

Changes at wind farm	Estimate	Lower Limit	Upper Limit
Pre-construction to Construction	1.35	0.70	2.63
Pre-construction to Operation	0.53	0.27	1.02
Construction to Operation	0.39	0.23	0.67

For the third contrast, the value of the test statistic is z=-3.49 and is significant at the 0.1% level i.e. ρ<0.001. The remaining contrasts show no significant difference.

Manx shearwater

Overall Totals	Ormonde	Reference
Pre-Construction (1 survey)	103	327
Construction (8 surveys)	116	190
Post-Construction (12 surveys)	313	1111

Changes at wind farm	Estimate	Lower Limit	Upper Limit
Pre-construction to Construction	1.94	0.71	5.30
Pre-construction to Operation	0.89	0.40	1.99
Construction to Operation	0.52	0.19	1.41

Examination of the data for the individual transects showed a great deal of variation, with several records of fairly large groups of birds combined with scattered singletons. This variability suggests that there is very little chance of detecting any changes for this species.

Appendix 5. Statistical outputs: Comparison of number of individuals between construction phases; comparison between May surveys only

Manx Shearwater. The table gives the May survey totals for this species.

Stage	Survey	Ormonde	Reference
Pre-construction	2009	103	327
Construction	2010	97	5
Construction	2011	0	55
Operation	2012	0	0
Operation	2013	3	7
Operation	2014	0	0

The following table gives the estimated changes in numbers at the wind farm site, based on comparison with the reference site, using data from just the May surveys.

Changes at wind farm	Estimate	Lower Limit	Upper Limit
Pre-construction to Construction	5.13	1.73	15.25
Pre-construction to Operation	1.36	0.03	61.66
Construction to Operation	0.27	0.01	12.69

For the first contrast (pre-construction to construction), the value of the test statistic is t=-3.01 and is significant at the 1% level i.e. $\rho<0.01$. The remaining contrasts show no significant difference.

Gannet. The table gives the May survey totals for this species.

Stage	Survey	Ormonde	Reference
Pre-construction	2009	51	69
Construction	2010	21	3
Construction	2011	1	6
Operation	2012	2	4
Operation	2013	3	3
Operation	2014	4	5

The following table gives the estimated changes in numbers at the wind farm site, based on comparison with the reference site, using data from just the May surveys.

Changes at wind farm	Estimate	Lower Limit	Upper Limit
Pre-construction to Construction	3.31	1.02	10.70
Pre-construction to Operation	1.01	0.55	1.87
Construction to Operation	0.31	0.06	1.51

For the first contrast (pre-construction to construction), the value of the test statistic is t=2.04 and just exceeds the 5% level of significance i.e. $\rho>0.05$ and there is no clear evidence of changes.

Kittiwake. The table gives the May survey totals for this species.

Stage	Survey	Ormonde	Reference
Pre-construction	2009	7	10
Construction	2010	16	4
Construction	2011	3	41
Operation	2012	17	7
Operation	2013	4	2
Operation	2014	2	0

The following table gives the estimated changes in numbers at the wind farm site, based on comparison with the reference site, using data from just the May surveys.

Changes at wind farm	Estimate	Lower Limit	Upper Limit
Pre-construction to Construction	0.60	0.06	5.86
Pre-construction to Operation	3.65	0.47	28.21
Construction to Operation	6.05	0.88	41.73

None of the contrasts between phases have an upper and lower limit either above 1 or below 1 and therefore there is no clear evidence of changes.

Lesser Black-backed Gull. The table gives the May survey totals for this species.

Stage	Survey	Ormonde	Reference
Pre-construction	2009	48	61
Construction	2010	17	19
Construction	2011	46	0
Operation	2012	5	0
Operation	2013	0	1
Operation	2014	1	23

The following table gives the estimated changes in numbers at the wind farm site, based on comparison with the reference site, using data from just the May surveys.

Changes at wind farm	Estimate	Lower Limit	Upper Limit
Pre-construction to Construction	2.94	0.52	16.76
Pre-construction to Operation	1.17	0.23	5.88
Construction to Operation	0.40	0.12	1.37

None of the contrasts between phases have an upper and lower limit either above 1 or below 1 and therefore there is no clear evidence of changes.

Guillemot. The table gives the May survey totals for this species.

Stage	Survey	Ormonde	Reference
Pre-construction	2009	54	121
Construction	2010	336	218
Construction	2011	31	75
Operation	2012	35	59
Operation	2013	18	34
Operation	2014	29	19

The following table gives the estimated changes in numbers at the wind farm site, based on comparison with the reference site, using data from just the May surveys.

Changes at wind farm	Estimate	Lower Limit	Upper Limit
Pre-construction to Construction	1.99	0.23	17.19
Pre-construction to Operation	0.75	0.09	6.47
Construction to Operation	0.37	0.15	0.91

For the third contrast (construction to operation), the value of the test statistic is t=-2.21 and is significant at the 5% level i.e. $\rho<0.05$. The remaining contrasts show no significant difference.

Appendix 6. Statistical outputs. Proportion of birds in flight.

Manx Shearwater. The tables summarise the survey totals for this species.

	Ormonde		Reference Area		
Date	Flying	Water	Flying	Water	Total
16/05/2012					0
08/07/2012	82	12	136	64	294
09/08/2012	6		8		14
08/10/2012	3		7		10
20/05/2013					0
18/07/2013	55	86	206	233	580
23/08/2013	1		6		7
25/09/2013					0
16/05/2014					0
12/07/2014	67	1	154	294	516
06/08/2014	1		2		3
11/09/2014			1		1
Totals	215	99	520	591	1425

A statistical test showed no evidence of differing proportions in flight at the two sites.

Gannet. The tables summarise the survey totals for this species.

	Ormonde		Reference Area		
Date	Flying	Water	Flying	Water	Total
16/05/2012	2		4		6
08/07/2012	13	5	28	84	130
09/08/2012	2	1	4	1	8
08/10/2012	1		6	8	15
20/05/2013	3		3		6
18/07/2013	12	2	12	6	32
23/08/2013	2		6	3	11
25/09/2013	3	1	3	1	8
16/05/2014	3	1	3	2	9
12/07/2014	16	1	15	11	43
06/08/2014	6		1		7
11/09/2014	7		5	2	14
Totals	70	11	90	118	289

There was evidence that a smaller proportion of the birds in the reference area were flying (t_{11}=2.85, ρ<0.01)

Kittiwake. The tables summarise the survey totals for this species.

	Ormonde		Reference Area		
Date	Flying	Water	Flying	Water	Total
16/05/2012	17		4	3	24
08/07/2012	78	42	3		123
09/08/2012	3	3		2	8
08/10/2012	1	2	8	22	33
20/05/2013	3	1	2		6
18/07/2013	34	49	1	3	87
23/08/2013	57	21	6	6	90
25/09/2013	3	17	7	1	28
16/05/2014	2				2
12/07/2014	18	32	9		59
06/08/2014	7	10	5	1	23
11/09/2014	4		3	3	10
Totals	227	177	48	41	493

A statistical test showed no evidence of differing proportions in flight at the two sites ($\rho>0.05$).

Lesser Black-backed Gull. The tables summarise the survey totals for this species.

	Ormonde		Reference Area		
Date	Flying	Water	Flying	Water	Total
16/05/2012	4	1			5
08/07/2012	12	11	6		29
09/08/2012	6	5	8		19
08/10/2012	8	1	5		14
20/05/2013			1		1
18/07/2013	16	13	20		49
23/08/2013	19	6	14	1	40
25/09/2013	10	7	7		24
16/05/2014	1		20	3	24
12/07/2014	15	6	22	40	83
06/08/2014	36	19	23	31	109
11/09/2014	11	2	11		24
Totals	138	71	137	75	421

A statistical test showed no evidence of differing proportions in flight at the two sites ($\rho>0.05$).

Guillemot. The tables summarise the survey totals for this species.

	Ormonde		Reference Area		
Date	Flying	Water	Flying	Water	Total
16/05/2012	5	30	11	48	94
08/07/2012	5	18	2	176	201
09/08/2012		5		20	25
08/10/2012	4	122	16	259	401
20/05/2013	6	12	13	21	52
18/07/2013		26		323	349
23/08/2013		58		64	122
25/09/2013	1	110	3	419	533
16/05/2014	6	23	7	12	48
12/07/2014	3	10	5	87	105
06/08/2014	1	6		18	25
11/09/2014	2	74	1	84	161
Totals	33	494	58	1531	2116

A statistical test showed no evidence of differing proportions in flight at the two sites ($\rho>0.05$).